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RELATING TO THE SUGAR INDUSTRY  
IN PERU

(WITH STATISTICAL MONITOR OF PRODUCTION CARRY-OVER)

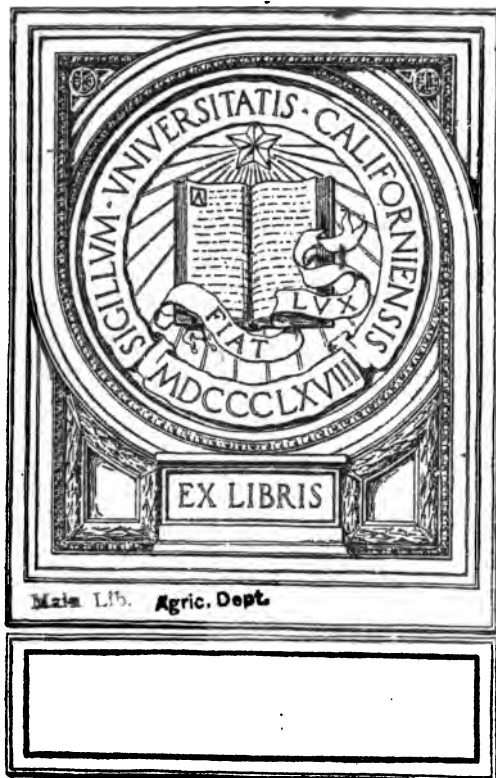
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THOMAS F. SEDGWICK.



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RELATING TO THE SUGAR INDUSTRY  
IN PERU.

(With special mention of Hacienda Cartavio.)

BY  
THOMAS F. SEDGWICK.  
H

DEPT. OF  
COMMERCE

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TRUJILLO PERU.

---

—IMP. HAYA, VERJEL & Co—

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1905.

SP 229  
14 11

Main City  
Office

TO VNU  
AIRPORT

W. R. Grace & Co.,  
Lima, Peru.

Dear Sirs:

In concluding my engagement with you covering a period of two years and a half, I am sending my report, which I have had printed at your request, hoping it will present a general idea of the conditions of the sugar industry in Peru, and that it will furnish some comprehensive data relative to the Hacienda Cartavio which you represent. The report is based upon my observations of various estates in different localities in Peru as well as upon my particular investigations at Cartavio.

There are probably few other individual estates in any country that have carried on such extensive investigations as those you authorized me to make at Cartavio. The estate is in fine condition and if its progress continues, it will not only hold its place among the foremost of Peruvian estates, but will compare favorably with the best estates in the best sugar growing countries.

In the laboratory work I have been greatly assisted by Dr. Baffi who has come from Germany to continue the Control Work that I have laid out. Senor Quevedo has been very efficient in calculating and arranging data for the laboratory and reports.

The conditions in Peru are most favorable to sugar cane growing and to a high production of sugar. The greatest needs at present for the sugar industry in this country are the development of the water supplies and the introduction of the most up-to-date milling methods and machinery.

Respectfully,  
T. F. SEDGWICK.

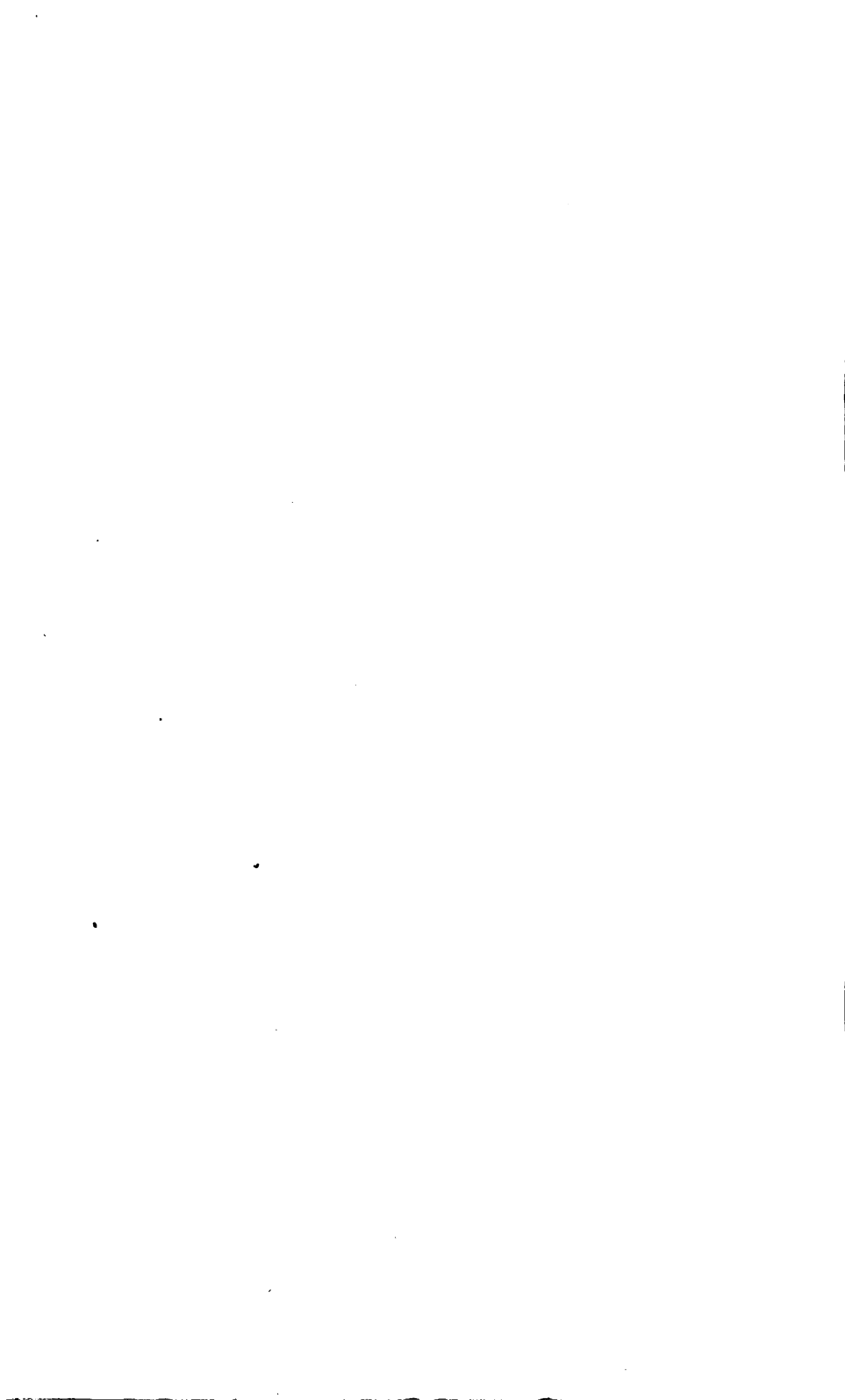
Trujillo, Peru.

It may be of interest to you to know that, so far as can be learned, this is the first publication printed in English in the city of Trujillo. The minor errors that have crept in can be readily pardoned when it is considered that the printers worked in a language with which they were unacquainted, and that inadequate printing facilities necessitated all corrections to be made "on the spot."



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## GENERAL CHARACTERISTICS OF THE SUGAR DISTRICTS.

Geographically, Peru lies within the tropical zone. The great back of the Andes running parallel to the coast and some miles from it, divides Peru into two agricultural divisions which are radically different as to climate and vegetation—the East or wet side, and the West or dry side. The East is the land of jungles, rains, and the head waters of the “Great River.” The resources of this part of Peru have not been fully exploited. Sugar cane does grow there, but at present the scene of activity in the development of the sugar industry is along the Pacific West Coast Strip. We speak only with reference to what has been learned of this West Coast.

From the West slope of the Andes spurs run out toward the sea to the coast forming valleys, some of which cover thousands of acres. The productive valleys are drained by rivers or streams. The areas beyond the irrigation limit of these streams or rivers present the appearance of a desert waste, but the soil is not usually a desert soil and needs only water to bring forth a luxuriant growth.

The primary agencies that helped to form the valley lands were undoubtedly terrestrial disturbances, inundations and recessings of the sea, etc.; but from an agricultural standpoint the most potent factor has been the erosive and depositive action of the mountain waters. The rivers have a flood and short season; during a few months of the year the waters from the Andes come down the gorges of the West slope in torrents, collecting at the head of the valley to form rivers which are sometimes augmented to floods. After the flood season, the water gradually subsides until only a small stream finds its way in the riverbed to the sea. It is the flood waters that have aided in forming the productive agricultural lands.

*Location.* The chief sugar growing regions at present are in the North Central, Central, and South Central valleys, the largest district being about 7 degrees South of the Equator.

### CLIMATE.

Although the West Coast of Peru is included in the geographical tropics and the principal sugar district is within 7 or 8 degrees of the Equator, the climate is not, as might be expected, truly tropical. The influences that have modified it are,—the cold ocean currents from

the Antarctic regions with the prevailing breezes that pass over them, and the high Andes.

The coast strip of Peru is notable for its small allowance of rainfall. Although in a few sections there may be copious periodic rains, the principal cane producing valleys depend on irrigation for their water supply. Considering the little amount of rainfall, a low relative humidity would be expected; but in fact, along the immediate coast it registers moderately high—72 to 84. Notwithstanding this, from an agricultural point of view it must be considered a dry climate. The effect is not that of a humid atmosphere; it is not steamy or enervating. It is interesting to note that remains of the ancient inhabitants are found naturally mummified, and cloth in which the bodies were buried is often found in a good state of preservation.

While the difference between the warm and cool season is keenly felt by the inhabitants, it is due rather to the winds from the cold current than to the actual difference in temperature.

The temperature of the upper sections of the valleys better sheltered from the sea, is a little higher than the lower sections.

The temperature of the Northern valleys is some higher than the Southern but not in proportion to the difference in degrees of latitude.

#### SOILS.

While there are many local variations in soils, every district or country has soils of particular characteristics which distinguish them as a whole. The similarity in the mode of formation of these valleys of Peru under cultivation would indicate the general similarity in the composition of the soils.

Physically, the soils vary from very fine sandy loam to silty. So finely divided is some of it that the entire sample will pass through the regulation sieve. The soils also vary in depth. Shingle can be found in some places two feet below the surface, while in others, the same characteristic surface soil (save for Nitrogen and organic matter) can be found at a depth of 15 to 20 feet or more. As a whole, they are deep soils and their physical composition (especially after much cultivation) renders them very retentive of moisture.

The underground drainage of most of the valleys is excellent. It is so complete in some places that from the cliffs bordering the sea, little rivulets may be seen emptying their waters into the ocean,—seepage waters of the valley above. (This is to be seen at Barranco). The valleys slope so gently to the sea that they appear a level plain; they

also slope slightly toward the river bed. The underground drainage strata vary in depth; in some of the lower lands, seepage water is found within a few feet of the surface.

*Chemical composition of the soils.* The soils are of the alkali type, some of them containing a considerable amount of water-soluble chlorides, sulphates, and carbonates which are found accumulated in the finely powdered surface layer. This is especially true of the soils along the coast.

These soils of the cane growing district are, as a whole, well supplied with the elements essential to plant growth. Lime is often very high as compared with some other cane growing countries. Phosphoric acid (total) is good, as is the amount of potash. Nitrogen is good, but is a variable quantity, depending for any given soil on the time it has been under cultivation, water supply, class of weeds or plants that have grown on it, and the amount of flood waters that have been allowed to cover it. (Adjoining the cultivated areas are large tracts of land formerly cultivated by the natives of the country centuries ago. Today the soil appears lifeless for want of organic matter and nitrogen. Long periods of rest from cultivation and irrigation have diminished the supply. With proper care this soil could be made remunerative though to an observer it appears hopeless.)

Organic matter is variable. The soils of most arid regions usually contain an excess of insoluble material and little organic matter. These soils digress somewhat from this rule, and are found to contain a fair amount of insoluble residue and organic matter although they are essentially mineral soils. This can probably be accounted for in the manner of their formation; humus is also higher than would be expected for the same reason.

Much of the lime in the soil is in the form of carbonate. In some places along the immediate coast, nitrates are found.

The mode of formation from the composition of the mother soil accounts for the natural richness of these valley soils under cultivation. Irrigation, cultivation and fertilization have modified them to a great extent and have occasioned many local differences that deserve special mention. In a word, they are naturally rich in plant food, retentive of moisture, easy of cultivation, and capable under proper treatment of great productiveness; they are generally deep soils, well drained, and approach as nearly the conditions of an ideal soil as can be found.

## SUGAR ESTATES IN PERU.

### ORIGIN OF THE SUGAR INDUSTRY IN PERU.

A translation from Ricardo Palma's "Tradiciones Peruanas" gives the following concerning the origin of sugar cane in Peru:

"Sugar cane was not known in Peru at the time of the Conquest. It was in 1570 that we had the first plantation. The sugar used in Lima was brought from Mexico. The first factory was established on an estate in the valley of Huanuco. Since the sugar it produced could not compete with that of Mexico, the owner of the factory resorted to a clever stratagem; that was, to send to Mexico a ship loaded with Huanuco sugar. The Mexican producers swallowed the bait for they supposed that to send them sugar from Peru was as much as to say, "send rosaries to Berberia"—that the production must be abundant and the price very low. They ceased, therefore, to send sugar from Acapulco, and the sugar industry began to flourish in Peru"

At the beginning of the modern sugar industry in Peru 30 or 40 years ago, the estates then established were small, each having its own factory and organization. The machinery was brought from Europe and the United States and put up generally in accordance with the ideas of the owners, and for this reason we have in Peru factories representing the workmanship of different nationalities. Some of the factories were not only splendidly but elaborately put up, and there are features in some of them that could well be adapted to the modern factory. Sugar was at a good price; money was easily made and liberally spent in appliances then in vogue. Some factories had much of their tubing, their pans, and all of the appliances that could be, made of copper. This desire to have the best regardless of expense extended to all departments of the estate. Sugar then took a turn and went down and many of the estates had to go out of business.

The movement at the present time seems to be towards the establishment of large estates. The smaller estates are being leased or purchased and the cane grown on them ground at the home factory. A few of the larger estates control an acreage of upwards of 15,000, half of which, perhaps, is in cultivation.

The "Small Cane grower and Central Factory" plan has been adopted to some extent in Peru, the cane grower having his cane

TRIP OF  
CARTAVIO



LOOKING TOWARD AN ESTATE SETTLEMENT. (Cartavio.)

TO YOU  
AIRBORNE

...

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...

...

ground at a central factory which may be an entirely independent organization. There are various arrangements between the planter and the factory. The cane grower delivers his cane to the factory; the factory grinds the cane, manufactures the sugar therefrom and takes for his pay 35% of the sugar and alcohol—the 65% being the planter's share. Some factories cut, transport, grind and manufacture the cane and receive 50 to 54% of the sugar and alcohol for their share. In some contracts it is stipulated that the juice must not register a density below a given degree Beaumé. Another arrangement which seems to be gaining favor is for the factory to buy the cane on the basis of a sliding scale which is controlled by the degree Beaumé of the juice, and by the prevailing market price of sugar in Liverpool. These different arrangements are of course modified somewhat according to local conditions and the pleasure of those interested.

The early estates manufactured sugar and alcohol for both export and home consumption. Many of them had a capacity of no more than 12 to 20 tons of sugar per day, or, say, 150 to 220 tons of cane in the 15 hours; but when it is remembered that they could grind throughout the year if necessary, the total amount of sugar that could be turned out from such an estate was considerable. Refineries were erected in connection with some of the factories for making the granulated white, cube, and loaf sugar. Both rum and alcohol were made from the waste molasses.

*Chancaca.* Chancaca is the sugar from the juice boiled down in open pans to the consistency of the massecuite. It is then run into molds about six inches in diameter and allowed to cool; it is then tied up in cane leaves and is sold for local consumption, bringing a good price. Factories were constructed solely for the manufacture of this product, and many of the sugar factories had a department for it. It is interesting to note that in the manufacture of chancaca, the "mass" is sometimes stirred by a revolving apparatus to promote hardness. This same process modified, is our present crystallization in movement.

The factories erected at this time were equipped with three roller mills, an open juice evaporator, small pan, bottom pulley centrifugals, massecuite cars on trucks or large wooden or iron massecuite tanks. The engines used for propelling the mill were often of the walking beam type. The bagasse was carried out in carts from the conductor, dumped in an open field, allowed to dry, and then fed to the furnaces. Where water was available, the crushing plant was sometimes run by water power.

While some of the factories in operation today are similar to those just spoken of, the tendency is to introduce modern appliances and methods. Financial or other conditions have not always permitted an entire reconstruction of the larger factories, and so both old and new methods and appliances are found together. The weeding out of the old is merely a matter of time. The better factories have installed dry double crushing. The mills are usually three roller of about the 32x66—32x78—34x84 type, some of them being fitted with hydraulic pressure apparatus. The mills are generally run by separate engines. The bagasse, with few exceptions, is still carried to the furnaces in carts and fed to the furnaces by hand. A few multitubular boilers have been introduced. The juice from the mills is more often run up directly to the defecators. The upright triple effect seems to be the most popular. There are a number of copper vacuum pans still in use and doing excellent work. Masecuite is handled in different ways; in some factories it is run into large tanks, and allowed to crystallize; then it is shovelled into boxes by hand and emptied into the centrifugals. In other factories, it is run into masecuite cars and allowed to cool; then it is dumped into a reservoir from which the centrifugals are charged. The sacks holding from 225 to 230 lbs. (Eug.) of sugar, are filled either by hand or from a shoot.

When the price of alcohol warrants, alcohol is made from the waste molasses. Some of the estates are equipped with good fermenting rooms and modern Coffey stills. The alcohol is stillled over in two grades—one of 40 degrees which is sold as alcohol and is about 95% alcohol, and the other, of 30 degrees which is sold as rum. The Government has an insight and control over the working of this department and the estate that wishes to make it must conform to the regulations.

By the gradual merging of the small estates into the larger ones, the number of estates and factories has been reduced. The following list, taken from the «Boletin de la Sociedad de Agricultura», includes most of the factories and estates that were in existence in 1903:

#### *Shipping Port.*

#### *Factories and Estates.*

Eten.

Tumán. Cayaltí. Pomalca. Pátapo & Tulape. Pucalá. Almendral.

Pacasmayo.

Lurifico.

*Shipping Port**Factories and Estates*

Salaverry.	Roma. Casa Grande. Sausal. San Antonio. Chicamita. Laredo. Cartavio. Nepen. Pampas. La Viniña.
Huanchaco.	Chiquitoy. Chiclin.
Chimbote.	Tambo Real. Vinzos. Suchiman.
Samanco.	San Jacinto. San José.
Supe.	Huayto. Paramonga. San Nicolas. Carretería.
Huacho.	Andahuasi. El Ingenio.
Chancay.	Palpa. Huando.
Ancon.	Caudivilla. Chuquitanta. Infantas. Huachipa Neveria. Naranjal. Chacra-Cerro. Chacra-Grande.
Cerro Azul.	Santa Barbara. Arana.
Callao.	Monte Rico. La Molina. La Estrella. Caraponga. San Juan. La Villa.
Tambo de Mora.	San Jose de Chíncha. Laran.
Pisco.	Caucato.
Chala.	Chocavento.
Arica.	Tomasiri.

## LABOR AND ORGANIZATION OF AN ESTATE.

### LABOR.

The bulk of the laborers are the natives of the country, descendants of the people found in Peru by the Spaniards at the time of the conquest. Their home is in the mountains where they grow small crops and carry on a little trading. They are brought to the estates by labor contractors.

At one time China was called upon to make up the labor deficiency. A number of importations of Chinese were made; the laborers were taken to the estates and entered into long contracts. When the contracts expired, most of them forsook the fields for something easier—preferably the fonda or restaurant and the small merchandize store.

As in all countries situated on the high road of sea travel, stragglers of many nationalities are to be found. The latest movement to increase the labor supply, was the introduction of Japanese. Reports concerning them are both favorable and unfavorable.

*Life of the laborer on an estate.* The immediate employment of laborers for an estate is through contractors who go to the mountains, or send to the mountains, for them. Negotiations between the estate and the laborers are made through the contractors. Petty difficulties between the laborers themselves are settled at the estate office. For drunkenness or otherwise disturbing the peace, the offender may be fined or shut in a room called the jail. Should the offence be atrocious, as in the case of a cutting affray, the matter is placed in the hands of the authorities of the nearest town.

The estate pays the wages through the contractor. It provides houses and rations per tarea. The laborers may live quite comfortably and independently, but they must conform to the regulations of the estate. During the week, for example, lights must be out at a certain hour. Playing on musical instruments or carousing after this time is punishable; but on Saturdays nights music, dancing, and all amusements may go on with perfect freedom. There are small stores and a market place or plaza where vegetables, meat, fish, clothing etc., can be bought. The baker, the tailor, the mikman and other tradesmen are represented here.

The larger estates make up a settlement of from two to three thousand inhabitants. They employ a physician whose services are gratis to all employees and laborers. A hospital is provided for the very sick patients; there is a drug store where medicines are dispensed free.

UNIV. OF  
CALIFORNIA



LABORERS' HOUSES. (Cartavio)

TO THE  
LIBRARY

The estates also provide schools, one for the boys and one for the girls. Amusements such as circuses and travelling theaters, are encouraged.

Not only the Government but the estates are alive to the fact that to get good work they must have good laborers and treat them well. In most sugar growing countries the difficulty seems to have been to induce the natives of that country to work in the fields, and importations from other countries have had to be made. If by harboring the interests of the native laborers, they can be induced to continue to work, Peru will have accomplished what many other countries have failed in.

*Stock.* The stock used on an estate are horses, small mules, and oxen. The animals are allowed alternate weeks of pasture and work. Cane tops and alfalfa are used as food.

*Tarea or task system.* On most of the estates, as much of the work as possible is done by the task or tarea. Cane cutting, cane loading, planting, and weeding are done in this way. It makes no difference so far as pay is concerned how much time a man puts in for he is paid only for the particular piece of work. The system is so well organized that the work can be laid out fairly to all. While each gang of laborers has its overseers, the relations between them are much pleasanter than with day labor because it eliminates the ever antagonistic element "drive". It has the advantage also of bringing out a laborer's aptitude for a particular work. The number of tasks a laborer has completed during the week are carefully recorded. A good deal of study has been given to this and the outcome is a pretty reliable system of checks and counter-checks.

The regular officers of an estate are about as follows: Manager, sub-manager, cashier, book-keeper, engineers, machinists, overseers, carpenters, blacksmith. Many of the estates are equipped with a laboratory for chemical work and employ chemists. They employ an attorney to attend to all legal matters. There are also Agencies representing them in the seaport where the sugar is shipped, and usually Agencies in Lima or Callao.

The estates are connected with adjoining estates and towns by telephone and railroad. Contracts are entered into with the railroads for the delivery of sugar to the port.

## CULTIVATING AND HANDLING CANE.

### PREPARING SOILS FOR PLANTING.

As most of the cane is grown on gently sloping land, all kinds of machinery for preparing the soil can be used. A piece of land to be put into cane is first cleared of any brush that may be growing on it, holes are filled up, and the turning up of the soil is done by the steam plow. (The latest introduction is the disc plow.) The field is plowed and cross plowed. If the land is new, it is divided off by roadways and drainage ditches into sub-sections as nearly square or rectangular as possible. A bird's-eye view of an estate gives the appearance of a checker board. The sub-sections once laid out in this manner serve until the next planting. After plowing, clod crushers and pulverizers are drawn over the field until the soil is reduced to powder.

*Laying off furrows.* The furrows are laid off in parallels of between three and four feet. To do this, stakes are set up in line across the field and the driver sighting along them guides his oxen so that each stake when approached hits the middle of the yoke; the yoke knocks it down and the driver sights on to the next. On the return trip, one oxen takes the furrow while the other walks on the outside. The furrow is made deeper by a larger plow and V'd by a double mould-board plow.

### PLANTING.

The field is now ready for planting. As it is the custom to plant tops of cane, these are cut in the field when cane is being harvested, loaded on cars and run to the fields that are to be planted. The seed cane is placed on the ridge of the furrow; then the planting gang lay it in the furrow horizontally and cover it with a few inches of soil. After the whole field is planted, water is turned on from the main section irrigation ditches and the cane left to sprout.

### CULTURE OF THE CANE.

After the cane has reached the height of about a foot, the weeds are removed after an irrigation. The field is cleared of weeds until the leaves of the cane have grown large enough to shade the ground and prevent their growth. The cane is allowed to grow for from 18 to 24 months depending on the locality, soil conditions, weather and N° of cut. Some weeks before harvesting the water is turned off of the field and the cane allowed to mature.



PLOWING AND LAYING OFF FURROWS. (Cartavio)

TO VMU  
ABORTED

[illegible]

TO VINU  
AMBORLIAO



V-ING FURROWS AND PLANTING CANE. (Cartavio)

When the first ratoon cane is a few feet high, the crest of the furrow is thrown into the furrow so making the irrigation water pass between the rows of cane instead of in the furrows and on the cane as it does with the plant cane.

The cane is recut as many times as it will pay. On some sections of this estate there have been canes cut four times only and it would not pay to cut again; while on other sections seven cuts have been made giving good results.

*Applying fertilizer.* The estates that fertilize use chiefly the native guano and sometimes ashes from the begasse plant. Fertilizer is applied differently by different planters; some throw it into the furrow with the cane, allowing it to remain some time before running on water; others distribute it along the furrows after the cane is a few months old and cover it up at once; still others distribute it along the furrows and turn the water on immediately. An effort is being made on some of the estates to grind both the guano and ashes; and also, to spread the fertilizer broadcast over the field just before replanting.

A few planters use lime and gypsum. Small importations of potash salts as well as chemically prepared fertilizers have been made, but these are small compared with the amount of guano used.

*Irrigating.* The irrigation waters from the river are led to the land by canals. From these the water is carried to the sections by smaller ditches running along the heads of the sections. From the section ditches it may be run directly to the cane rows. As the rows are parallel, and the land slightly sloping, the water flows freely from the upper to the lower end of the section. Some times the water is allowed to pass from a cuartel to the one below through small connecting ditches cut in the roadway. Water is held in the furrow by daming the lower end. In addition to these irrigating ditches, drainage ditches are sometimes dug along the lower portions of the section to secure better drainage for the soil and to collect the water passing over alkali lands.

As yet no system similar to that in Hawaii (the contour irregular furrow system) has been observed, and owing to the almost level fields and the fact that the soils are less porous than those of Hawaii, it is doubtful whether it would prove of advantage here.

Irrigation by pumping water from wells is not generally practised. There is one pumping plant on the Cartavio estate that derives its water from filtrations. The total depth of the hole is about

35 feet; the underground seepage waters collect there and are thrown up by a centrifugal pump. Characteristic water washed stones were found in this well.

It is interesting to note that the cuartel above the well is becoming dry, showing the effect of drawing on its sub-surface waters.

The amount of water required for the growing of cane is small compared with Hawaii. This is on account of the character of the soil and the existence of underground water so near the surface. If water were used as freely on some of the lands here as in Hawaii, the result would probably be disastrous. It is the practice at Cartavio to give the plant cane considerable more water than the ratoon. While many of the sections have by no means had all the water they really need, large crops have been obtained. Some sections seem to require much less water than others.

The following table shows the number of times the cane has been watered during its growth on certain sections of the Cartavio estate:—

Sec. A	Plant	Cane	21 times	Sec. F.	Ratoon	Cane	10 times
" B	"	"	21 "	" G	"	"	13 "
" C	"	"	13 "	" H	"	"	10 "
" D	"	"	21 "	" I	"	"	11 "
" E	"	"	24 "	" J	"	"	9 "
				" K	"	"	8 "
				" L	"	"	14 "
				" M	"	"	12 "

Each estate is allowed a minimum of water during the short season, the amount being regulated by law. During the flood season, it is not so carefully regulated because there is more than enough for all. The irrigating canals leading direct from the river are often guarded by a man appointed from the estate to see that he gets his rightful share. There are Government officials whose duty it is to visit these canals or tomos; should any difficulty arise between the different estates as to the water supply, it is referred to the Water Commissioner who considers the conditions and decides the case.

The water is measured by the "Riego".

Sometimes the river changes its course during the flood season, or may be partly changed by the planter by erecting dykes.

#### HARVESTING THE CANE.

When the cane is ready to cut a gang of men is set to work with



AN IRRIGATION DITCH. (Cartavio.)



knives or machetes of the regulation type, cutting, stripping, and topping the cane. As the work is done by the piece, some of the cutters become very skillful and are able to prepare the cane with a few strokes of the knife. A main portable track is run down to the section that is being cut, and from this switches are run off into the fields. The cars are loaded by hand, the canes being put crosswise to the length of the car, and drawn to the main track by oxen. The train of cars is taken to the factory by a locomotive.

*Cars.* The cars used for transporting cane vary from the 2 to 3 ton cars to the 8 to 10 ton.

*Weighing the cane.* The factories are equipped with a balance. The loaded cars are run on to the balances and weighed before passing to the conductor. Scales of various kinds are used. Weights are generally taken in kilos or metric tons, and if desired, transferred into the English or Spanish system. One estate has a registering balance; the weigher simply balances the machine, pulls a lever, and takes out a paper slip with the weight recorded on it.

*Unloading the cane.* The cars at the side of the conductor are unloaded by hand, the men feeding the conductor evenly and steadily and removing objectionable material. About 26 men are employed at the Cartavio factory to unload 400 tons daily, unloading at two conductors.

## PERUVIAN SUGAR CANE.

Three varieties of cane have thus far been observed—the white, or the whitish yellow, the greenish yellow, and the red or red purple. An uncultivated variety grows along the roadsides which may be a degenerated offshoot of the canes now in cultivation. The red or red purple cane is not so extensively grown for sugar as the others, but it is interesting on account of its resistance to alkali, and is selected for certain alkali soils.

While the Peruvian canes are affected by the borer, their rather hard rind and high fiber protect them to some extent so that the borer is not so disastrous as in many other places.

The variations in the saccharine qualities of the cane grown in Peru are due chiefly to methods of growing. The percentage of sucrose may be as low as 12 or as high as 17.5, but, generally, the cane is of the high fiber, high sugar, low moisture class. The juice, usually, is of good purity; its manufacturing qualities are excellent. The sugar house products, syrups, first massecuites, are consequently clean. Refactory juices are rare. The sugars produced are of good color, rather large grain, high polarization, and, in most cases, good shippers.

The soil and climate are conducive to heavy yields. While in most districts it requires from 18 to 22 or 24 months to mature the cane, it is said that cane matures in some localities in 16 months.

On certain lands under very favorable conditions it will probably be found that 90 tons of cane can be grown on small areas, and that some estates can be made to produce an average of 60 tons and upwards an acre—this, of course, under intensive cultivation. At present on good estates, the average is probably from 35 to 45 tons per acre.

The figures below give a fair idea of the qualities of some average Peruvian canes:—

Sucrose in cane, %	15.77
Fiber in cane, %	15.00
Moisture in cane, %	66.02
Density of juice, Brix	20.87
Sucrose in juice, %	18.71
Purity of juice,	89.68
Ash in juice,	.47
Gums in juice,	.45
Tons of cane per acre,	40.00

## INTRODUCTION OF NEW CANES.

At least two foreign varieties have been introduced,—one from Demarara, and one from Hawaii. So far these canes have shown no qualities superior to the native canes, and that from Hawaii has not done as well. This cane was planted on new land containing alkali spots. On another soil it might have behaved somewhat differently, but comparing it with the home cane grown on the same soil and considered as giving poor results it did not make any better showing. The table below relates to this experiment:

	<i>Hawaiian Cane</i>	<i>Home Cane</i>
Tons of cane per acre	37.89	37.3
Sucrose in cane %	12.42	13.03
Fibre in cane	14.90	15.08
Moisture in cane	68.73	67.44
Density of juice, Brix	16.80	18.11
Sucrose in juice	14.60	14.35
Glucose	.80	1.08
Purity	86.90	84.72
Glucose ratio	5.40	7.00

The introduction of better classes of cane is not the most vital problem in the industry for Peru, but new varieties should always be under test in the experimental plot. The new varieties should be immediately inspected by a responsible person appointed for that purpose. After careful fumigation or other treatment if necessary, they should be placed in an experimental plot not only for trial as to their qualities, but to see that no disease or pest has accompanied them. Should they prove of more value than the home canes, they can be propagated for distribution among the planters, or large installments obtained directly from the country in which they were grown.

## FERTILIZERS FOR PERUVIAN SOILS.

Fertilization or fertilizing is usually limited to mean the application of fertilizer to the soil. The terms *fertilization, fertilizing, soil management, soil rectification*, should mean any treatment of the soil whatsoever, that will tend to put it into a sound healthy condition for the production of any given crop, or qualities especially desired for that crop. The application of fertilizers (manures, guanos, green manuring etc.) is only one phase of fertilization. A soil may be put under fertilization, or be fertilized (made more fertile) without the addition of a pound of fertilizer.

Fertilization by means of fertilizers is the subject here considered.

The object of applying fertilizers to cane is to secure more sugar per given area. As the cane is a gigantic grass and the sugar is contained in its stem, the main thing is to get quantity and quality of stem. If we were dealing with a plant whose leaves, fruit or seeds were the parts utilized, the method of fertilizing would be quite different. Fruit trees might be fertilized as cane is with the result of much wood but little fruit.

*Influence of climate and soil on fertilizers.* With a soil and climate such as Peru possesses, fertilizers are readily made available for the use of plants. In most sections of Peru the growth of cane is gradual requiring a rather long time to mature, though there are three or four months in the year when the cane grows vigorously, out of proportion to the gradual growth of the other months. This may happen twice in the life of a cut. This vigorous growth is advantageous provided the cane can be kept growing gradually after this period, and that the change from the rank to gradual growth be not too sudden. This change is not caused so much by a marked lowering of temperature as by the shorter days with consequently less sun, and the damp mists from the ocean that spread a chilling blanket over the lower portions of the valleys.

If a powerful stimulant were given the cane in the warm season of naturally rapid growth, the growth would be so rank that the cane could not keep it up during the cool season. If a powerful stimulant were added during the cool season, the possible effects on the cane would not be realized. The kind of fertilizer needed, therefore, is a moderately slow acting one; such a fertilizer would be one containing a good amount of plant food elements but with only a fair proportion

of them immediately available.

Since the soils are usually deep, contain a large amount of lime and a fair proportion of water-soluble salts, fertilizers are easily decomposed and slow acting fertilizers undergo a more rapid decomposition in these soils than in many others.

*Kinds of fertilizers to apply.* As most of the soils are alkali and contain sulphates, chlorides and carbonates, care must be taken not to increase them. Chlorides would be increased by the addition of potassium chloride. As the sulphates are the least harmful of the three, sulphate of potassium is the best source for potash when potash is imported. Chilli saltpetre has a tendency to increase the amount of soluble soda. Its use on some soils as a stimulant may be beneficial; as a fertilizer, it must be used guardedly. Canes that have been injured by insect attacks will sometimes be restored to normal growth by the use of chilli saltpetre. It also helps to prevent tasseling, and a very little will be beneficial when nitrogen is applied in organic compounds that are not quickly decomposed. Its action on cane is to produce a sudden rank growth, and if used in large quantities acts very much as an alkali. It has a tendency to make the juice gummy, and so might interfere with the elaboration. The time to use it is when the cane needs a stimulant. Every estate should keep it in stock.

Dried blood, tankage, the meals, etc. are good sources of nitrogen for these soils as they are slow in their action. The Peruvian guano approaches as nearly a perfect fertilizer as any outside of those chemically prepared, since it contains both nitrogen and phosphoric acid, soluble and insoluble, and a little potash. It acts as a stimulant to the young cane and is a source of reserved plant food. The phosphoric acid added in the guano may not all be used by the cane, but comparatively little is lost and its addition to the soil is not injurious. While the natural guano may not be in the proportions of a high grade fertilizer, it is excellent and cheap, and for these soils, if mixed with potassium sulphate would make an almost perfect fertilizer.

*Quantity of fertilizer to apply.* This depends on the kind of soil and the class of cane desired. Some soils need building up as well as plant food, and it may be better to add fertilizer in large quantities for a few years with the aim of getting the soil into healthy shape; after that, the fertilizer may be added pretty nearly in the proportion that the cane would remove it from the soil. There will always be some loss of fertilizer in the irrigating water. The highest development in the art of fertilizing would be to know how to add the least amount

of fertilizer to produce the best results. This point will need to be studied in Peru when the guano supply gives out and high grade fertilizers must be resorted to. Experiments will help to determine it. On these soils, from 1000 to 1500 lbs of guano carrying 8% nitrogen have been used per acre; where large quantities are used, the aim has been the upbuilding of the soil.

*Applying fertilizers.* The ideal way of feeding cane would be to give in only a little fertilizer at a time but give it often. This, however, is hardly feasible for most estates, and in fertilization as in all other departments of the work, the financial and practical must have precedence over the theoretical.

Putting on fertilizer twice or three times might pay; two applications are, perhaps, best. One application should be made as soon as possible after the cane sprouts; and the second, six or eight months later. If fertilizers are put in with the seed cane when it is planted, they should be those that are not easily soluble in water, as there would be no advantage in applying those easily soluble in water. If fertilizer is cheap, spreading it broadcast over the field would be a good practice; but as commercial fertilizers are usually expensive—a ton containing more or less 150 lbs of nitrogen at 12 cts (gold) per lb, and a fair crop of cane removing about 130 lbs of nitrogen per acre—the planter must economize in its use so he needs to place it where the roots can get at it easily. If the fertilizer is placed along side the growing cane some inches below the surface of the ground, it will be within easy reach of the roots which do not grow very deep. Fertilizer should be covered up with a layer of dirt to prevent the escape of ammonia, if it is in the fertilizer, and to prevent the removal of the fertilizer by the irrigating waters and its consequent uneven distribution over the field.

Guano left on the surface is subject to a number of disadvantages;—one is the leaching by irrigation, another is the encouragement of shallow root growth, and another is the loss of ammonia by exposure to the air. Analysis shows the loss of ammonia by exposure to be 1.6%. While the loss in the field would be less than this, it would be enough to warrant covering with earth. The percent of nitrogen in the guano before drying was 9.3; after drying, 8.

An important reason for not placing the guano on the surface of the soil is because an upward instead of a downward root growth would be encouraged since it is the nature of roots to follow the food supply; the plant would, therefore, be less firm in the ground and

less resistant to drought.

After the application of fertilizer, water may be run on the field, but only enough to moisten the earth thoroughly and not in sufficient quantities to cause underground drainage. After the first irrigation the fertilizer will be pretty well set. A good practice is to apply the fertilizer, cover it up, and allow the cane to remain without irrigation for several days.

At present, fertilizer is put on the field by hand, but with the parallel furrow planting there is no good reason for not applying it with a fertilizer drill particularly with ratoon crops. Should some of the soils be too hard to permit drilling on plant cane, fertilizer could be drilled on the surface and covered by a single plow.

*Fertilizing plants and ratoons.* As planting is a matter of considerable expense, the more cuts the planter can make the greater will be his profits. A strong rooted plant cane is more apt to produce a good ratoon than a weak one, and for this reason the plant cane should receive as large an installment of fertilizer as it can take without producing an over rank growth. Ratoons should have an abundant supply of fertilizer placed along their roots underneath the ground. By judicious fertilizing, one or two additional cuts may be obtained.

It would seem that in Peruvian soil as a whole, the element most needed is nitrogen, in some instances potash, and of lesser importance, phosphoric acid and lime. The soils are naturally rich containing a good supply of food elements that need only to be made available. Some of the soils are almost inexhaustible. Owing to their lime and other elements, they permit the addition of fertilizers in large quantities. A fertilizer that would be well adapted to most of these soils is one containing about 8% nitrogen, 6% potash, and 3% phosphoric acid.

## SOURCES OF FERTILIZER.

Peru has been particularly favored in the matter of securing fertilizer. The great guano deposits have supplied nitrogen, phosphoric acid and some potash. The soils themselves are generally well supplied with lime. The close proximity to the saltpetre fields has made it easy to secure the fertilizing elements, except potash, with little difficulty.

These abundant supplies of the richest kind of fertilizer have made the planter less alive to the general scarcity in the world of nitrogen, phosphoric acid and potash. The time may come when these supplies will be exhausted and the consideration of new sources of fertilizer supply will be as important in Peru as in other places,

To secure nitrogen, phosphoric acid and potash, refuse and by-products of some of the manufactures may be utilized. Among the materials that may be used and which the country supplies in varying quantities, are dried blood, tankage, cottonseed meal, ashes, leather scraps, fish scraps, and even street sweepings. New sources of fertilizer may be discovered as the country abounds in minerals, soluble salt deposits of various natures, and, as there is so little rainfall along the Coast, it is quite possible that some of the elements such as potash may exist.

An interesting indication of this is to be seen along the Coast of the Chicama valley. For a number of miles along the Coast where the present river has spread its filtration water, there are shallow layers of soil heavily charged with salt containing a small proportion of potassium nitrate. In some of the best of these soils, analyses showed about  $1\frac{1}{2}$  to 2 % water-soluble potassium nitrate. The deposits, so far as yet observed, seem to be very shallow and in pockets. No fair estimate of the amount existing in this locality can be given.

The potassium nitrate is now obtained as a by-product of the salt industry, which is carried on in much the following manner: The earth is gathered, and brought to a central plant where it is placed on an improvised filter usually made of wild cane stalks, weeds and leaves. It is then washed with water which passes down into a collecting gutter and then to a receiving tank. This liquor,—dark colored owing to the dissolved organic matter—is boiled in kettles to such a point that the nitrate will crystallize out; this is indicated by the Beaume hydrometer. The liquor containing the salt is then drawn off and boiled down until the salt crystallizes out. Both products are refined by reboiling with fresh water; after crystallizing out and drying,

they are ready for the market. The nitrate is at present sold for the manufacture of powder, and brings 5 cents (gold) per pound.

These deposits were probably caused by the leaching of the upper valley soils by the irrigation water and river drainage. The potash and other salts contained in the waters were finally deposited in the lower levels of the valley near the coast.

#### BAGASSE ASHES AS FERTILIZER.

As the cane contains a considerable amount of potash in its ash (18 to 24 %), the bagasse would naturally have a potash as well as phosphoric acid value. If the bagasse were burned so that there would be a gradual but complete incineration, the percentage of available potash would be comparatively high. The percentage of ash in the bagasse is about 1.25 %, and the percentage of bagasse from the present type of mills is 32 to 34 %, so that the actual amount of available potash for an estate grinding 120,000 tons of cane would be considerable.

Few bagasse furnaces give an ash containing all its potash in an available form. This is shown by the presence of a quantity of slag which would have little influence if applied to the soil.

The application of bagasse ashes from most of these furnaces must not, therefore, be considered as having a fertilizing value equal to the same amount of carefully incinerated bagasse.

The following analysis shows the proportion of elements in the bagasse ashes of some Peruvian cane:

#### Analysis of Bagasse Ashes. (Hda. Cartavio)

Sand, etc.	64.76	Oxide of Sodium	3.47
Colloid silica	0.73	Carbon etc. (difference)	1.77
Phosphoric Acid	3.64		<hr/>
Chlorine	1.37		100.62
Sulphuric Acid	5.34		<hr/>
Oxide of Iron etc.	1.70	Less Oxygen=Chlorine	0.62
Oxide of Calcium	3.52		<hr/>
Oxide of Magnesium	2.42		100.00
Oxide of Potassium	11.90		

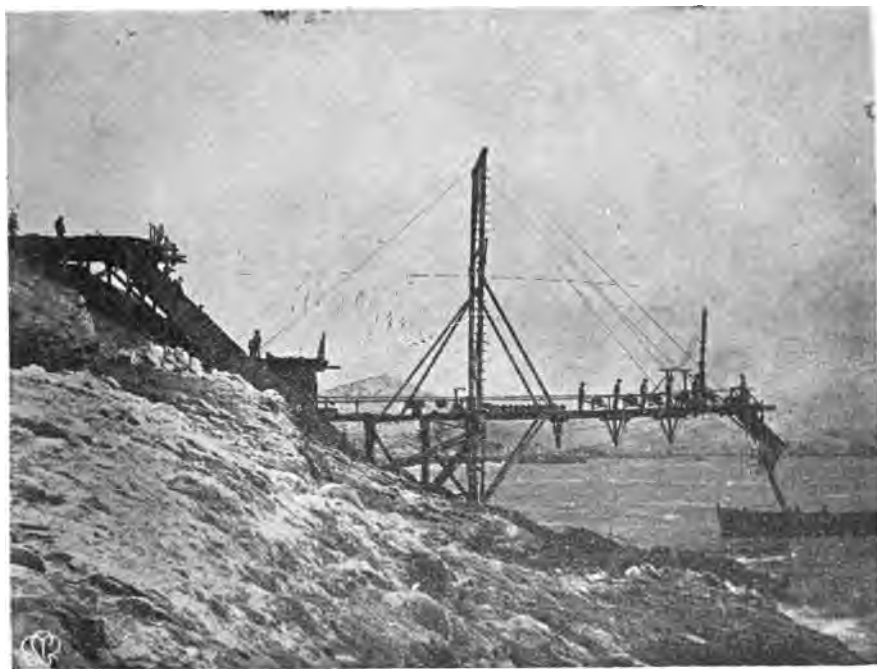
## THE GUANO OF PERU.

Along the coast of Peru there are many islands varying in size from projecting rocks to islands of some miles in circumference. For ages sea birds and seals have made their homes in the sheltered coves and nooks. The fish brought ashore for their young, the excrement of the birds, the dead bodies of the birds, and even the eggs, have contributed to this supply of phosphoric acid and nitrogen. Deposits have sometimes been found under a considerable layer of earth or sand. They may be composed of a thick stratum of pure guano, or intermixed with sand and earth and shells.

Some of the nitrogen contained in these guanos is in the form of free ammonia and other easily decomposable compounds. So strong is this ammonia sometimes that the fumes given off from guano stored in the hold of the ship are almost unbearable. The preservation of so much of the nitrogen is due to the lack of rains that would leach it out. The dry sheltered spots where the guano is found have been an almost perfect storehouse where decomposition could go on making the fertilizing elements in a reasonably available form and yet conserving them. In this respect these islands differ from most of the guano islands of the Middle Pacific; there, the phosphates are high but the nitrogen is rather low.

About 1845 shipments of guano began to be made to Europe and other countries, and soon the Peruvian guano gained a world wide reputation. At the present time the exportations of guano are limited. The agriculturalists in Peru are permitted to gather guano for their estates by conforming to certain regulations. In this way an excellent fertilizer containing a fair quantity of two of the costly elements of plant food can be obtained at a very reasonable figure. Few other countries are so blessed in this respect.

The guanos of Peru may be divided into three classes: those containing a high percentage of phosphoric acid and comparatively low nitrogen; those containing a fair percentage of phosphoric acid and high nitrogen; and those containing a fair amount of each. The first class is exported to considerable extent; the second class is found only in small quantities; the third class is the one used by many of the estates and is of value chiefly for its nitrogen, as many of the soils are already well supplied with available phosphoric acid. This class has many features peculiar to chemically prepared fertilizers.



LOADING GUANO. (Island Lobos de Afuera)



The following analyses show the proportions of phosphoric acid and nitrogen in each of these types of guano:—

	Sand and silica.	Moisture.	Phos. acid.	Nitrogen.	Amm.
1st Class	11.24	—	24.60	3.20	3.88
2nd "	.80	18.00	14.80	13.50	16.40
3rd "	19.80	12.50	9.18	8.40	10.20

*Physical properties.* While the guano is often mixed with small stones, pebbles, sand, and material containing phosphates, a good proportion of it is very finely divided and only needs sifting to make it ready for the field. Some of the guano reaches the estate in the crude form containing large lumps which are nothing but caked manures easily disintegrated, and if leached with water give a straw colored solution containing a good amount of nitrogen and phosphoric acid. A guano like this needs but little mechanical treatment to give it the physical condition of a chemical fertilizer.

*Chemical conditions.* This guano is equally interesting chemically. Some of the phosphoric acid is immediately available and is soluble in water; other portions are soluble in the "Citric Solution". Still more interesting is the character of the nitrogen, some of which is in the form of free ammonia. In some of the guanos the total water-soluble nitrogen amounts to 2.5%. Potash is present in small proportions,—.5 to 2%.

The following analyses show the composition of some of the Peruvian guanos:—

Island "Lobos de Afuera" (chiefly for export).

Volatile Matter %	Sand %	Phos. Acid. %	Nitrogen. %
23.11	4.00	32.57	1.47
27.53	23.03	20.22	3.14

From Other Islands.

Sand and Silica.	Moisture.	Phos. Acid.	Nitrogen.	Amm.
8	10	11.50	9.60	11.90
15.20	10.70	11.20	8.20	9.95
21.10	12.50	18.70	3.24	4.92

The export guano is sold in accordance with the analysis of the guano which considers moisture, sand and silica, nitrogen and phosphoric acid. This has led to the establishment of laboratories on the principal guano Islands. If a class of guano is not up to the standard, it is rejected or used as a reducer for guanos of extremely high grade. The guano for home use is often purchased without any definite agreement as to quality; but some of the estates that have laboratories demand a guano of a more or less certain analysis. By long years of practice, the contractors who gather the guano are able to distinguish different qualities without the aid of a chemist. They fit themselves out with a schooner and go from Island to Island until they have a cargo. Some estates have secured as high as 2,500 tons per annum.

## PESTS.

The pests in Peru affecting the sugar cane have been little studied. It is to be said that those that are here may be kept under control if not entirely eliminated, provided there are united efforts in this direction. This is true for the following reason: The cane belt of a valley is that portion accessible to irrigation waters; outside of this belt very little plant life exists. (A good example of this is the strip of cultivated land in the Chicama valley lying between the large barren tracts towards Trujillo on one side, and towards San Pedro on the other.) The pests must confine themselves to the fertile areas as there are no other places for them to feed, and as these fertile areas are practically isolated, the work of extermination is made easy, and a valley once cleared of a pest would not often be revisited.

The borer seems to be about the only insect pest that has materially influenced the growth and quality of the cane. There are occasional local attacks of other insects. The presence of fungus has been noticed on canes that were grown on wet soil and had fallen down.

While the natural conditions are not favorable to the increase of pests, they may get the upper hand if neglected. In the case of pests, "an ounce of prevention is worth a pound of cure", and the best preventative is strict regulations for all plants brought to the country. An insect or a fungus harmless in its natural environment, may become a dangerous pest in new feeding grounds. A careful inspection should be made of all plants entering the country, and if diseased, they should be rejected or subjected to treatment. This work cannot be satisfactorily carried out without proper equipment and a trained entomologist.

*Controlling pests.* There are two distinct schools or methods for the control or eradication of pests. One advocates the use of chemical mixtures for sprays; the other advocates the introduction of parasites to prey upon the pest. Both have their advantages and disadvantages; in the case of chemical sprays, there is the danger of killing beneficial as well as destructive parasites; in the introduction of parasites, there is the danger of their becoming pests under new environments.

*The cane borer in Peru.* As cane has been grown in the country for over three hundred years, it is probable that the borer has inhabited the cane fields for a long time. The effect of the borer on Peruvian cane will not be as disastrous as in canes of many other

countries because the cane, generally, contains a high percentage of fibre. The actual damage wrought by the borer is not so much the hole made in the cane as the deteriorating effect on the surrounding tissues which may cause a considerable loss of sugar. The natural sap flow is impaired and the cane can not make so vigorous a growth. Analyses of the affected and unaffected parts of cane have been made. The results showed that the affected tissue contained only  $9\frac{1}{2}\%$  sugar, while the healthy tissue contained  $14\frac{1}{2}\%$ . The proportion of affected tissue, however, is usually small.

*Controlling the borer.* In the sugar world a number of remedies have been tried with more or less success. Parasites have been found that are said to prey on certain species of borer. Stripping the cane is advised; cutting the young borer out of the cane; cutting off the young shoot containing the borer; planting the cane at certain seasons; killing all weeds on which the borer lives; flooding, and varying the methods of cultivation and irrigation.

A combined war against the borer, systematically carried on, is probably the only sure means of getting rid of them whatever methods or means may be used, and can be most successfully and economically effected under the direction of a trained entomologist who understands their life history and local habits. Investigation for the control of the borer should receive the same attention that the improvement of the soil or fabrication does.

Burning the trash in the field is a partial control of the borer. Certain canes are more resistant than others. The stronger any plant is the better it will resist pests, and for this reason it is best to select for planting, canes with few borer holes. The laboratory at Cartavio keeps an account of the average number of borer holes in the cane per section; in this way an idea is obtained of the increase or decrease of the borer, and a standard set for the selection of cane for planting.

The borer may be spread by planting infested cane, by hauling cane from an infested district to the factory, and by laborers carelessly throwing a cane containing borers into a field.

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## ALKALI SOILS.

A soil is composed chiefly of the following elements in varying compounds and proportions: Silicon, iron, aluminium, calcium, magnesium, sodium, potassium, manganese, sulphur, carbon, oxygen, hydrogen, nitrogen, phosphorus, and chlorine. Should any one or several of these compounds occur in proportions out of the normal, the soil is designated by that peculiarity. Some of the Hawaiian soils, for instance, contain abnormal quantities of iron and aluminium and are therefore distinguished as a particular type of soil. Alkali soils are soils distinguished by a predominance of the compounds of the elements of sodium, calcium, magnesium, and often potassium. The compounds may be in the form of sulphates, carbonates, chlorides and nitrates in varying quantities; those usually predominating are sodium carbonate, sodium sulphate, sodium chloride and the corresponding compounds of magnesium and calcium.

### FORMATION OF ALKALI SOILS.

If soil and salt are mixed together and water filtered through and collected, the water will be found to contain some of the salt that was mixed with the soil. If the water containing the salt is passed into soil containing no salt and not allowed to drain through, the water on evaporation will leave the salt in the soil.\* If more water containing salt is passed into the soil and allowed to evaporate, it also will leave salt behind increasing the amount added by the first application of salty water. If this is repeated a number of times, the soil will contain crystals of salt, and if the amount is sufficient the once fertile soil will not support ordinary plant life.\*\*

(\*) Water may pass into soil not only from above the surface, as when a piece of land is irrigated or rained on, but it may be drawn up to the surface layer of soil from the underground drainage waters by capillary action.

(\*\*) A striking instance of this occurred on an estate in Hawaii as described in an article in "The American Sugar Industry And Beet Sugar Gazette," from which we quote: "\*\*\*Up to about four years ago it was a steady dividend paying corporation with a stock quoted above par. It had fertile lands, though not a great acreage, and an abundant supply of artesian water which was pumped into the irrigation ditches by a pumping plant of good construction and large capacity. As none of the water had to be pumped to any great elevation, the expenses of pumping were not excessive, and the plantation made money. But there was salt in the water that was pumped on the land. There was not a

This dissolving of salt by water and its depositing on lands, is what has taken place in the formation of alkali soils formed by erosion, flooding, or filtration. Lands that have recently been covered by the sea leaving salt marshes along the sea coast, are sometimes called alkali lands; but alkali lands are here understood to mean lands in which the accumulation of certain salts in the soil has been produced by the action of soil waters.

#### FORMATION OF ALKALI LANDS IN PERU.

The conditions that have brought about the alkali lands of Peru are,—the character of the mother soil, the dry climate, the formation of the valleys and the way they are drained.

As much of the agricultural land of the valleys was formed by erosive action, it should represent some of the characteristics of the mother soil. If this had contained a good quantity of decomposable salts, they would be expected to be found in the valley soils. If these valley soils had been washed by rains and the drainage water run off to the sea, many of the easily soluble salts would have passed off with it. But, as there is very little rainfall in the middle and lower portions of the valleys, they were not leached out. After repeated soakings with waters containing the salts, and subsequent evaporations, the soils became sufficiently charged with them to be distinguished as alkali soils.

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great deal of it, and for years it did not interfere with the fertility of the soil, and the fact of the presence of the salt in the water was unknown by many, forgotten by others, and overlooked by all but the most careful. However, there came a time when the constant pouring of salt on the land showed its inevitable effect. About four years ago, apparently all at once, the former fertile soil seemed to refuse to respond to cultivation, and cane ceased to grow. The smash came as sudden and complete as that of the wonderful one horse shay. From a crop that had been sufficient to pay satisfactory dividends, there was first little or no crop, and of necessity no dividends, \*\*\* There was consternation among the stock holders, many of whom never dreamed of the true situation. But a portion of the stockholders faced the situation resolutely. They began an inquiry into a remedy for the difficulties that beset them. Finally a plan was evolved for the entire abandonment of the pumping plant and artesian water system and the construction of a ditch to bring water from the mountains to supply a gravity system of irrigation.\*\*\* As indicating the immense amount of salt which accumulated in the soil year after year by the use of the salt artesian water, the manager reported that when the drain ditches were first constructed, the water they carried off contained 200 grains of salt to the gallon, while a year later it contained only from 25 to 50 grains." This plantation is now on the high road to prosperity and is expected soon to pay dividends again.

If by copious rains these salts could be dissolved and carried to the sea, the soils would be normal soils. Or if irrigation water were allowed to run over the soils and the soils properly drained, they would be normal soils. Alkali lands are caused, then, by deposits of easily soluble salts in lands where there is not sufficient water or proper drainage to remove them. Alkali will usually be found in the lower levels. In the Chicama valley, for instance, the salts have been carried from the upper to the lower portions and because they could not find their way to the sea, have been held and accumulated. There is a splendid example of the formation of alkali lands now going on on one of the estates near Lima; the waters from the mountains are concentrated in a large sink hole that is difficultly drained; the salts are being deposited and the alkali is becoming so strong that the surface crust will burn the tongue in exactly the same way as sal soda.

In countries where there is rain, this same dissolving of salts from the mother soil goes on, but the rains prevent the accumulation. Nature has her compensations; and though the rains prevent the accumulation of alkali by carrying off the salts to the sea, they also carry off some of the elements valuable for plant growth, so that where there is much rainfall the soils generally, are not so rich in mineral plant food as in districts of little rainfall. Alkali lands must not, therefore, be classed as poor or bad lands.

Because the valleys are comparatively short and slope gently to the sea, and because there is an excellent natural drainage system, the alkali lands in Peru will never become so extensive nor so difficult to handle as in many other countries having soils of this nature.

#### LOCAL DISTRIBUTION OF ALKALI IN THE VALLEYS.

While the formation of the alkali lands was due, primarily, to the action of river waters, the alkali was confined to smaller limits than at present, and its distribution may be accounted for by the irrigation waters.

Many of the valleys have been under cultivation for hundreds of years. The water for irrigation was obtained from the rivers and was distributed over the valley by the construction of dams, aqueducts and sub-ditches. The farmer appreciating the necessity for economy in the use of the water, probably did not allow any more than was actually necessary to leave the field, and the water on evaporation left its salts until they accumulated in sufficient quantities to affect the crops. Incrustations appeared on the surface of the soil, and the crops

began to fail. The most natural way to remedy the evil was to remove what he saw; this he evidently did as piles of earth containing alkali are to be seen in the districts where alkali exists. While temporary relief was gained by this process, conditions were constantly being made easier for increased accumulations, since every time he scraped the soil, the level of that particular spot was lowered.\*

#### APPEARANCE AND DETECTION OF ALKALI AREAS.

In an uncultivated soil it is not always easy to distinguish an alkali spot. There are signs, however, which may indicate its presence. If certain grasses which prefer alkali soil are found in the field among other plants, it is safe to say that the land on which they grow is alkaline. This is especially true for some of the salt grasses. If an area is without growth, and the first surface inch or two of soil is in the form of a fluffy powder that burns the tongue, it will usually be found to be alkaline.

After a soil has been turned over by the plow it is impossible to distinguish the alkali prior to irrigation. After an irrigation, it is easily discerned either by a white incrustation on the surface, a dark brown color in patches, or by areas of soil whose surface layer remains moist long after the irrigation period. These moist spots are particularly in evidence in the early morning, evening, or on a foggy day.

If a soil after being wet and dried becomes exceedingly hard and difficultly worked with the plow, it is partial evidence that alkali of a particular type is present.

A strongly alkali spot in a field of cane may sometimes be detected by the appearance of the cane growing on it. The cane will seem

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(\*) The ancient inhabitants of Peru have had some influence on modern agricultural conditions. The country must have been thickly populated in their time as signs of their labors are to be seen in localities that would hardly have been selected but for overcrowding. It is said they terraced the mountains in order to get lands to plant crops. They built dams to control the water, and they constructed long water ways to distribute the water to land that would otherwise be unproductive. In fact, they seem to have developed agriculture as then known to its fullest extent. They raised many crops of which corn seems to have been one of the most important. It is said they knew the value of the guano and that the seabirds that helped to make it were held sacred. By changing the course of the irrigating waters, they have altered somewhat the area of cultivable land. Some of the soils have been made better by their cultivation, and some have been injured because by their methods of scraping and irrigating, the alkali has been increased.

to be suffering from drought; the leaves will be yellowish and the stalks stunted.

#### COMPOSITION OF ALKALI.

In an alkali crust the compounds usually predominating are, sodium carbonate, sodium sulphate, sodium chloride, and compounds of calcium and magnesium. There are three types of alkali soils,—the white, characterized by an excess of sodium sulphate; the black, by an excess of sodium carbonate; and the salt, by an excess of sodium chloride or common salt. Either of the three may contain all of the compounds.

The black alkali is by far the most disastrous to plant growth and the most difficult to handle. It is produced by the change of certain sodium compounds such as sodium sulphate (white alkali) into sodium carbonate. It is commonly called sal soda; it turns red litmus to blue, and burns if taken into the mouth. The dark color of the soils containing it is due to its combination with organic matter; existing alone, it is white.

#### EFFECTS OF ALKALI ON THE CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES OF SOIL.

Where moisture is present, the alkali salts (including calcium salts) aid in the important work of decomposing organic material. This decomposed material in turn, will combine with some of the alkalies to form new compounds which would otherwise be unavailable for

One feature of their labors is of particular interest—the Huacas or mounds. Throughout many of the valleys may be seen piles of earth varying in size from small knolls to huge mounds 60 or 70 feet high and sometimes covering an area of one or two acres. There seem to be two types of mounds; those made of adobes (usually the larger mounds) piled one upon another and carefully cemented with mud, and those that are merely piles of earth. Those of the latter type may have originated through the efforts of the farmers to protect their crops by scraping up the alkali and throwing it into piles. The soils of these piles will often be found to be of the same character as the soils surrounding and to contain a considerable amount of the alkali of that section—in some cases, as much as 1.83 % water-soluble chlorides, and 2.85 % water-soluble sulphates.

There are various theories as to why these Huacas were constructed. They may have been temples, lookouts, or protections against enemies. Some of them were assuredly burying places and not only are bones found in them, but pieces of pottery, household utensils and trinkets, for the dead had personal belongings buried with them, and food and drink for use when making the "Long journey".

use by the plant. For this reason, a soil on which alkali weeds and grasses have grown will be found to be rich in available plant food. If a soil containing a large percentage of humus and sodium carbonate is washed with water, the leachings will have a black color showing that the sodium carbonate (black alkali) has dissolved the humus, and, consequently, a good proportion of the available plant elements are being washed away; so that, in general, where there are large quantities of alkali, the soil has really been improved so far as accumulating a supply of plant food is concerned.

After an irrigation, soils containing an excess of black alkali may be covered over by a hard crust impervious to water and not easily disintegrated, which by no means improves the physical condition of the soil but rather counteracts the benefits of previous cultivation. In some soils this layer is formed below the surface and so greatly hinders the natural drainage.

A soil containing a predominance of common salt alkali will have the property of securing and retaining moisture. The hygroscopic power will be high. An analysis of the crust of such a soil showed its hygroscopic moisture to be 32 %. It is owing to this that salty lands will support a certain kind of plant growth without irrigation. Calcium chloride in sufficient quantities will have the same effect.

While a large amount of white alkali in the soil is not desirable, its presence indicates that the general condition of the soil is better than in the case of excess of chlorides or carbonates.

#### EFFECT OF EXCESSIVE ALKALI ON CANE.

Both the soil and cane are benefitted by a moderate amount of alkali; the harm begins when the alkali is sufficient to interfere with the natural functions of the growing cane.

Seed cane is planted in the trough of the furrow and covered with a few inches of earth. The alkali in the soil collects in the first few inches of surface soil. The seed cane would lie, therefore, just where the concentration of alkali is greatest. If the alkali is strong enough, the buds are killed immediately in the same way that they would be killed if soaked in a strong brine. If the alkali is not strong enough to kill them directly, the roots may sprout but they will have to battle continually against its harmful influence. Although all the elements of plant food may exist in the soil in the most assimilable condition, the plant cannot properly utilize them for its normal development because its tissues are constantly being attacked and destroyed, and



**AN EXCEPTIONALLY STRONG ALKALI SPOT ON WHICH CANE WILL NOT GROW.  
(IT NEEDS ONLY PROPER WASHING TO MAKE IT VERY PRODUCTIVE.)**

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1. The first part of the paper is devoted to the study of the properties of the function  $f(x)$  defined by the equation

its energy must be devoted to replenishing feeble tissue, instead of making new tissue for growth. The cane once stunted or injured will feel the effects throughout its life. The ratoon crop may partly recover but instead of four or five profitable cuts there will probably be but three.

The yield of cane per acre is naturally influenced by an excess of alkali not only because there may be small areas on which nothing will grow but also because the cane that is grown may be stunted.

It has been interesting to observe that the alkali has not seemed to influence the manufacturing qualities of the cane to the extent that might be expected; the manipulation of irrigation water has seemed to exert a greater influence over them than do the salts in the soil. On a strongly alkaline soil, with an *excess* of water, a cane will be produced of fair fibre (14 %), low sugar (13 %), low purity (80 to 85 %), high glucose (.7 to 1 %), low density, high ash and high gums. On the same kind of soil but with a *moderate* supply of water, a cane with the opposite qualities will be produced, that is, high fibre, high sugar, high density, high purity, low glucose and low ash.

#### EFFECTS OF IRRIGATION ON ALKALI SOILS.

Water passing over an alkali spot from one section of cane to another may take up a portion of the salt and deposit it on the section below. Or, if the water is held on the soil it may increase the alkali in two ways; by adding to the already accumulated alkalies in the soil, and by dissolving the salts in the under strata which on evaporation will be brought to the surface.

Through years of cultivation and irrigation, not only has the topography of the valley been changed with reference to the alkali deposits, but the chemical constituents of the alkali have been modified. Some of the elements, potash in particular in a most available form, have been removed. The continued application of irrigation water on some of these lands has dissolved out a portion it along with other elements and carried them to the lower lands near the sea. The *less* soluble phosphoric acid was left behind. If this washing had not gone on, the soluble potash salts would have remained in the soil and there would have been little need today for applying potash on some of the soils. There probably are soils in Peru well supplied with potash and therefore no universal recommendation can be made for the application of potash on all Peruvian soils. The analyses of Cartavio

soils indicate a rather low percentage of available potash as compared with phosphoric acid.

#### RECLAIMING ALKALI SOILS.

The reclaiming of alkali soils is simply putting them into a normal condition by getting rid of the excess of obnoxious salts, which in some cases, would mean the loss of valuable plant food for which so much is paid in fertilizers.

There are four ways of improving alkali soils,—by scraping the soil, by growing certain crops, by using gypsum, and by flooding and drainage.

*Scraping the soil.* As the alkali comes to the surface and is there found in its most concentrated form especially after an irrigation, the surface layer can be scraped off; when the accumulation occurs again, the operation can be repeated. The difficulty with this method is that each scraping lowers the ground a very little and by repeated scrapings covering a number of years, it will be sufficiently lowered to make a sink hole where the water carrying salts may collect and on evaporation deposit a new crust of alkali. The result is that only temporary relief is gained.

*Growing crops.* There are plants that thrive on alkali soils or at least, tolerate it. Many of them are absolutely worthless for stock food or any other purpose at present known except to increase the organic material of the soil. Such plants when removed naturally take with them a certain amount of salts among which are the alkalies.

There are a few plants having an economic value that will grow on rather strongly alkaline soils and in the course of a few years would remove a fair amount of alkali provided the irrigation water did not bring down as much as the crop removed.

Alfalfa, Australian salt bush, and the sugar beet are among the useful plants that tolerate a considerable amount of alkali. Alfalfa has been grown in this country for fodder for a long time; it has aided in the removal of the excess of alkali from the fields but not to the extent that it would have done were less water required for its growth. The Australian salt bush grows on alkali soils without irrigation and is, therefore, a good agent. As a stock food it has valuable qualities though it is not one of the foods that stock usually crave.

The results with the sugar beet in the alkali lands of the Chino

Valley, California, were rather surprising. It was found that the sugar beets would grow well on soils that were believed to be too strongly charged with alkali to permit even a feeble growth. The sugar beet can be grown on the alkali soils of Peru; it would serve as a partial reclaimant and, possibly, a good rotation crop. \*

Cane does not remove the obnoxious salts from the soil to any great extent. The analyses of the ashes of equally nutured cane stalks from alkali and from non-alkali soils vary but slightly. The percentage of lime, soda, and magnesia are about normal in both. As an alkali removing plant, therefore, cane cannot be considered of pronounced value apart from the slight amount that it would naturally remove.

*Use of gypsum.* On soils containing an excess of black alkali, gypsum has the effect of converting the black into the white alkali, that is, changing the carbonates to sulphates. As mentioned before, the deteriorating effect of the white alkali is much less than the black and it is a choice of the lesser of two evils; the salts are not removed but the conditions for plant growth are improved.

\* In considering the rotation of crops, the idea suggested itself that the sugar beet, if it would thrive in Peru, would be a good crop for this purpose, and at the same time give a product that would not require radically different appliances for its manipulation. The difficulty with crop rotation for a large estate is that the estate is not usually prepared to handle the rotation crop and that it might require knowledge and experience quite different from cane growing. Where alfalfa is used for pasture the problem is easy; but with cotton or barley for the rotation crop the problem would be different as the work of the estate would need to be changed more or less to meet the needs of the rotation crop. A man thoroughly acquainted with cane growing and the manufacture of sugar, might have little ability in growing barley or tobacco, both of which would probably thrive in Peru.

As the climate is dry with moderate temperature, it was believed that the sugar beet would mature. Seeds were accordingly obtained, planted, and a few beets harvested; though small they contained 15% sugar which would indicate that beets of considerable value could be grown. From another planting, one beet not fully matured weighed 4 lbs. and contained 12 1/4 % sugar.

The difficulty in beet growing here would not lie so much with the climate, as with the soil some of which is of the finely divided packing type. On the sandy soils, particularly near the river bed, the beets would probably develop to fair size.

They will grow better if planted in the cool months; planted in the warm months they grow too much to top. These sample beets were planted in the warm months and harvested when five months old. Seed planted in soil containing a large percent of alkali gave a very rank growth of tops.

The question deserves consideration.

### FLOODING AND DRAINAGE.

*This is the one true and permanent method of reclamation if thoroughly carried out.* As the salts composing alkali are easily soluble in water, except the black alkali which can be made so by the use of gypsum, the remedy is to dissolve them and draw them off.

To do this, the land to be reclaimed is carefully treated with gypsum, if it contains black alkali, then flooded and drained by sub-drainage. At the lower end of the piece of land there should be a drainage ditch sufficiently deep to collect the seepage waters. If the land is a large tract, other sub-drains should be dug at convenient intervals but all leading to the main drainage canal. The water run on the field is allowed to drain out through the soil from below. After this, the land is flooded and the operation repeated until the soil has been thoroughly leached.

The success of the reclamation will depend on the thoroughness of the work; if the soil is only partly washed, enough alkali may still exist to hinder the proper growing of cane. Simply running water on the soil and allowing it to stand without subsequent drainage will only make matters worse because when the water has evaporated the salts absorbed from the under strata will be found accumulated at the surface. Allowing the water to pass over the surface and then off into a ditch is not effective; some of the alkalies are washed away, it is true, but those below still remain. Thorough flooding and thorough drainage are all-important.

The time required for complete reclamation will depend on the location of the land relative to the great valley drainage system, the character and quantity of salts present, and the rapidity with which the water drains through the ground. If, after flooding and drying, no trace of a crust is to be found, it is pretty sure evidence that the work is complete.

Tile drains are advantageous but in Peru where the natural drainage is so good there is less need for this additional expense.

### IRRIGATING CANE GROWING ON ALKALI AREAS.

This has been spoken of indirectly in other places but a few points may be added here.

The best way is, of course, to reclaim first and irrigate according to the usual methods. It often happens, however, that there is not enough water for thorough washing, or that the cane already growing would not bear the addition of so much water, or that there are

only a few small spots in the field. Where there are only a few small spots, it is better to run the irrigating water around, instead of over them. Where larger areas of alkali are concerned, it is better to run the water on and off as quickly as possible.

If irrigating water has passed over a field badly infected with alkali, the same water should not be used for other fields. A good practice, but one that might not be practicable owing to the labor it would require, is to draw a layer of fine dirt over the irrigated furrow before the water has completely evaporated. This hindered evaporation would help to prevent the alkali from coming to the surface. The same effect is produced when the cane is high enough for the leaves to shade the ground. This is one of the reasons why cane grown on some alkali spots will make a fair stand if it has been able to secure growth enough to shade the ground.

The question of fertilizing cane growing on alkali lands has been spoken of in general under Fertilizers For Peruvian Soils.

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## MANUFACTURE.

It is almost impossible to give a comprehensive description of the factories and methods of manufacture in Peru, as they vary considerably; but the following description aims to give a fair representation of the best factories in the country though no single factory has been strictly adhered to.

### MILLING.

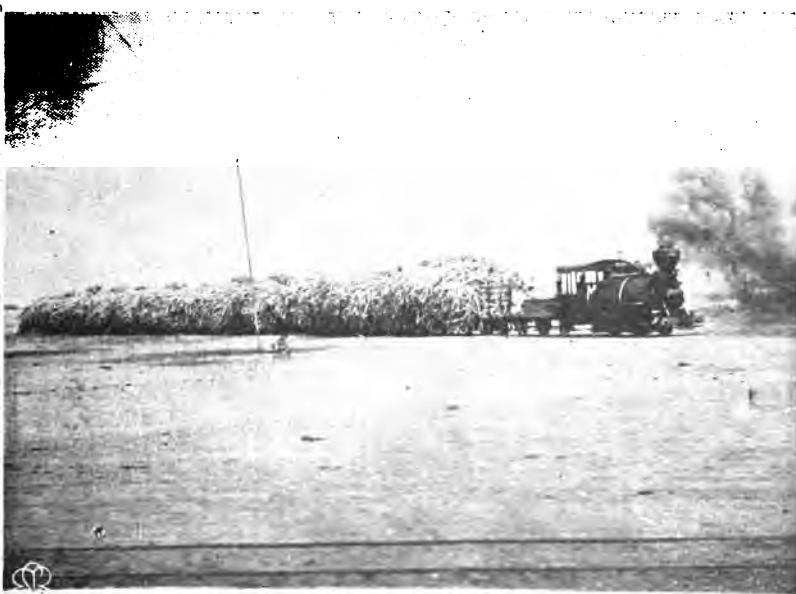
The cane after being weighed is run in the cars along side of the conductor and there fed to it by hand. It then passes up to a dry double crushing plant of two three roller mills fitted with hydraulic pressure. The cylinders may be of the  $32 \times 66$ , or  $32 \times 78$ , or  $34 \times 84$  type. Two men at the end of the conductor regulate the feed. The cane after passing through the first set of three rolls is run up to the second, passed through, and the bagasse carried off in a bagasse conductor. At the discharge of the second mill, two laborers pick out the badly crushed pieces of cane and throw them in to be re-crushed. The juice from the first and second mills is strained through a copper netting. The bagasse that does not pass the mesh is collected and passed through the mill again. The juices from the two mills are led through pipes or cement gutters to a well where they mix.

The mills are propelled by separate engines; in some cases these are of the walking bean type. The speed of the mills is about 22 ft. per minute for the first mill, and 11 ft. for the second.

The "extraction of juice over weight of cane" by such mills will vary from 62 to 70 % depending on the cane. The cane that will give a juice of 23 Brix and 21 % sugar, will give an extraction of 62 to 64 %; the moisture in cane will be about 64 %, fiber 16 to 17 %. On a cane giving a juice of 19 Brix, 17 % sugar, 13 to 14 % fiber, and 68 to 69 % moisture, the extraction will be 68 to 70 %.

The "extraction of sugar in cane obtained in juice" ranges from 75 to 83 %. The moisture in the bagasse ranges from 45 to 48 %. The sucrose lost in the bagasse is from 2 to  $3\frac{1}{4}$  % on weight of cane. The amount of sugar obtained in the juice calculated over weight of cane, runs about  $10\frac{1}{2}$  to 13 %.

The bagasse is run out from the conductor where it is dumped into carts and taken out to dry or carried to the furnaces direct. The furnaces, fitted with step-ladder grating, and usually placed below the ground surface, are fed by hand. Carts and wheelbarrows take the



LOADING CANE IN THE FIELD.      A TRAIN-LOAD OF CANE.  
(Cartavio.)







UNLOADING CANE AT CONDUCTOR.      A TRAIN-LOAD OF SUGAR.  
(Cartavio.)

ashes to the dump where they are left or taken to the fields for fertilizer. Both the old type and multitubular boilers are used; the large factories have from 8 to 12 boilers.

#### ELABORATION OF JUICE.

The juice from the wells is pumped up to the double-bottom copper defecators of a capacity of 400 to 500 gallons (in some factories it is first run through a juice heater). There it is limed to the neutral or slightly alkaline point, and tempered. The amount of lime used for such defecators is from 8 to 10 lbs; it is added either dry or as milk of lime. After defecation which requires from three quarters of an hour to an hour and a quarter, the juice is drawn off, clarified, filtered, and run to the tank feeding the upright triple effect. (Some factories do not clarify after defecation and some do not filter juices. No sand filters have been observed.) The deposits are delivered to the filter presses, and this filtered juice also goes to the triple effect tank. The press-cake is removed from the press and thrown into the dump.

Sulphur, phosphoric acid, or other chemicals are not needed in these juices which have an average analysis of about—Brix 20, sucrose 18, glucose .5, purity 88 to 90, gums .44, ash .47.

The clarified juices are pumped up to the upright triple effect, and after evaporation are discharged at 24 to 30 Beaumè into the eliminators which are fitted with copper coils. They are there worked up, skimmed, allowed to settle, and drawn off to the tanks for feeding the vacuum pan.

Analysis of an average 1st syrup:—Brix 52.86, sucrose 47.8, glucose 1.83, purity 90.

The scums are run to the scum tank where they may be blown up to a tank to be worked over, or made into mostos.

The vacuum pans, often of copper, have a capacity of from 10 to 15 tons. The syrup is drawn into the pans, grains started, and the strike boiled off, requiring from four to eight hours. The massecuite is discharged from the pan at about 94 Brix.

Analysis of an average 1st massecuite:—Brix 93.24, sucrose 83.4, glucose 3.90, purity 89.

The massecuite is discharged into massecuite cars holding something over a ton. The cars are run out on rails and allowed to cool from ten to twenty-four hours; they are then weighed, hoisted by an elevator to the floor above, run up over the mixer, and there dumped

by a hand dumper. The massecuite passes through a grating into the reservoir from where it is fed to the centrifugals. In the centrifugals (the overhead pulley of about 30 inch type), the massecuite is centrifugalled from four to ten minutes at about 1000 revolutions a minute.

The rendiment of 1st sugar over weight of massecuite is 60 to 63 %.

The sugar is discharged from below on to an apron or suitable conductor on which it is carried to a cup elevator which takes it to the drying room. The drying process consists in allowing the sugar to remain on the floor for a number of days with occasional turnings. It is then shovelled into a shoot over the bagging room. Bags are filled from below, weighed, sewed up and loaded into cars for shipment or stored in the storing room. The 1st sugar is from medium to large grain and polarizes about  $96\frac{1}{2}$  to 98; color, amber; crystals fairly regular; some false grains; some broken crystals; shipping qualities, excellent.

The molasses from the 1st sugar is collected from the centrifugals in a gutter back of the centrifugals which leads to a molasses well from where it is pumped to tanks fitted with steam pipes. There it is clarified, and then run to the eliminators.

Analysis of an average 1st molasses:—Brix 75.18, sucrose 52.80, glucose 7.01, purity 69.

The scums are drawn off and the 2nd syrup (clarified 1st molasses) is run to the feeding tank for the vacuum pan. From there it is drawn into the vacuum pan and boiled down to grain. It is discharged into massecuite cars and allowed to remain from twenty-four hours to a number of days. The massecuite is then weighed and purged in the usual way. The 2nd molasses is worked up for 3rd massecuite. After leaving the pan where the 3rd massecuite is boiled to a string, it is run into tanks holding 8 to 10 tons and allowed to crystallize for a number of weeks or a month if necessary.

The 3rd molasses is sometimes used to make 4th sugar but more often it is made into alcohol.

Analysis of an average 3rd molasses:—Brix 88.26, sucrose 36.8, glucose 15.38, purity 41, ash 9.

*Making of alcohol.* The molasses is drawn off to a mixing tank where it is diluted and reduced to a density of about 8 Beaumè. It is then run into large vats where it is allowed to ferment to the lowest point Beaumè without encouraging deteriorating fermenta-

tion. In order to promote fermentation, guano is sometimes thrown into the vat with the mostos. When properly fermented, the mostos is drawn off to the still, sometimes of the coffey type. After distillation, the exhausted mostos passes into the drainage ditch. The alcohol is run to vats in the alcohol room. The 30 degree distillate is called run and is kept separate. The alcohol is put up in tin containers of six gallons capacity, boxed and sealed. The revenue on alcohol is considerable and is based on the per cent of pure alcohol in the commercial product.

Sugar house work in Peru has not yet been so systematized as to make it possible to secure full and accurate data concerning it. But from notes gathered from several particular factories, a few are selected to supplement the general description.

While some of the data may be more or less approximate, it is sufficiently illustrative. The canes worked upon by these factories contain about 14.25 to 15.75 % sugar. The juices occasionally contain as low as 15.5 and as high as 21.5 % sucrose; but generally, they do not vary much, the usual juice containing 17 to 18 % sucrose.

#### FACTORY No. 1.

One three roller mill. Cylinders about the 32 × 66 type. Speed of mills 16 to 18 feet per minute. No hydraulic pressure apparatus. Extraction of juice over weight of cane, 58 to 60. 12 men unloading cane at conductor. Grinds 350 to 420 tons of cane per day. Works 15 to 20 hours. Bagasse dried in field and fed to furnace by hand. 7 boilers—5 in use. 1 tubular boiler. Weighs all cane ground in kilos. Weights, kilos. Cuts about 2000 acres annually. Turns out about 35 tons of sugar per day. Plenty of bagasse.

Density of juice, Brix, 18 to 20. Sucrose, 17 to 18.50. Glucose .3 to .8, average, .5. Average purity 88 to 90. Rendiment of sugar over that indicated in juice, 87. Eight double-bottom copper defecators. Working capacity of defecator, 414 Imp. gallons. Applies lime dry; uses 8 to 10 lbs. per defecator. Time for defecation, 35 to 45 minutes. No juice heater. Juice is run to a rectangular clarifier fitted with steam pipes, worked up and run to triple effect tank. Juice is

not filtered. Six filter presses for scums and deposits. Peruvian lime used; quality only fair.

Vacuum of 1st chamber triple effect 4 to 8; second chamber 14; third chamber 22. 1st syrup is discharged at 24 to 26 Beaumé; prefers 24. 1st syrup worked up in eliminator. Scums and deposits from syrups sent to the presses. 1st, 2nd, 3rd molasses clarified with a little lime.

Vacuum in pan 25 to 26. Pressure 50 to 55 lbs. Temperature 160 F. Time for strike 6 hours (straight). Massecuite discharged in cars of about 2700 lbs. capacity. Weighs massecuite in cars. Weighs sugar from massecuite in cars. About 100 cars used. Rendiment of 1st sugar over weight of massecuite 65 to 69. Makes four sugars. 1st massecuite cooled 12 to 24 hours. Has centrifugalled direct from pan with good results, but with somewhat lower rendiment. 2nd sugar cooled from 30 to 40 hours in cars.

4th massecuite discharged into tanks; allowed to remain one to two months or longer. Rendiment of 2nd sugar over weight of massecuite 50. 2nd sugar grained in pan; 3rd and 4th boiled to string. Two iron pans. 1st sugar large grain and very regular; color excellent; polarization 97 to 98; crystals very brilliant. Rendiment of sugar over weight of cane about 9.25 to 9.75. Massecuite cars run up to reservoir, massecuite dumped into mixer by hand dumper; massecuite then passes into overhead reservoir which feeds battery of centrifugals of about 30 inch type. Revolutions of centrifugals 1200 per minute. Requires about 5 minutes to centrifugal charge of 1st massecuite. All sugars worked in the same battery. Centrifugals bottom discharge. Sugar raised to floor above by cup elevator. Dries sugars on floor. Cars in which bags of sugar are loaded are run into the storehouse direct.

Mostos is made to 8 Beaumé; reduced to 3.5 to 4 Beaumé. 4th molasses used for mostos. Still for alcohol made in the Country.

Has recovered on a few sections over 5 tons of sugar per acre. Uses guano, ashes and some lime on soils. Manager states that guano has good effects on the following as well as the same cut to which it was applied. Soils contain some alkali both black and white. Estate situated near head of valley. Climate warmer than estates nearer the coast.

#### FACTORY No. 2.

One three roller mill. Cylinders 34 × 84. No pressure on

mills. Speed of mills 15 ft. per minute. Mills propelled by engines of walking beam type. Has balance but weighs cane only occasionally. Grinds about 350 to 375 tons of cane per day. Metric system of weights used. Extraction of juice over weight of cane 57 to 60.

Double-bottom copper defecators used; capacity 375 Imp. gallons. Density of juice, Brix, 18 to 20. Juice heater heats juice to 185 F. Uses a little sulphur in juice at times. Uses  $3\frac{1}{2}$  to 5 lbs. lime per defecator. Juice limed to slight alkalinity. Rendiment of sugar indicated in juice, 86.

Two vacuum pans, one copper, one iron; capacity of larger pan 18 tons. 2nd sugar grained in pan; 3rd boiled to string. Incorporates second massecuite. 1st massecuite allowed to cool in  $2 \times 4 \times 4$  ft cars for 24 hours; 2nd massecuite for 48 hours; 3rd for number of days or weeks. Massecuite cars elevated to floor above, massecuite dumped into mixer and then to reservoir. Do not weigh massecuite. Two batteries of centrifugals; one, overhead pulley bottom discharge, 30 inch type; the other battery of centrifugals, bottom pulley, 40 inch type. Revolution of centrifugal 1000 to 1100 per minute. Makes three classes of sugars. Sugars dried in centrifugals. Occasionally sugars treated in centrifugals with a little hot molasses. Polarization of 1st sugar 97.3. 1st sugars worked in separate battery. Grain medium. Color rather dark. Crystals regular. Good shipper.

Steam plant both old type and tubular boilers. Plenty of bagasse. Bagasse dried in field and fed by hand. Total weight of bags filled 227 lbs. (Eng).

Four cuts of cane made. Cane irrigated every three weeks. Soil requires plenty of water. Soils contain some alkali. Uses guano as fertilizer. Estate in upper part of valley. About 15 miles straight line from coast. Climate warm.

### FACTORY No. 3.

One dry double crushing plant. Three roller mills. Cylinders  $32 \times 78$ . Mills propelled by separate engines—walking beam type. Mills fitted with hydraulic pressure apparatus. Registering balance used. Grinds about 500 tons of cane per day. Grinds 33 tons per hour. Average extraction 68. Speed of mills—1st mill  $22\frac{1}{2}$  ft. per minute; 2nd mill  $18\frac{1}{2}$ .

Aims to secure juice with density as high as possible (this depends on the manipulation of water and time of cutting). Average purity of

juice 87. Uses double-bottom copper defecators. Limes juices to alkalinity; 8 to 10 lbs. of lime per defecator. Filters juices. No juice heater. Juice run direct from defecators to presses. No sulphur or other chemicals used in juice. Requires 35 to 45 minutes to defecate. Total evaporating surface of triple effect 4500 sq. ft. Vacuum of first chamber of triple effect 8; second 18; third 27. 19800 litres of juice evaporated per hour at 12 to 35 Beaumè.

Copper vacuum pans. Boils off strike in  $3\frac{1}{2}$  hours. Pressure on pans 40. Vacuum 28. Grains 2nd sugar in pan. 3rd and 4th boiled to string. 1st massecuite discharged from pan at 93 to 95 Brix. Discharged into cars of  $1\frac{1}{4}$  tons capacity. Analysis of 1st massecuite—Brix 93.55, sucrose 83.66, glucose 3.09, purity 89.42, ash 1.90. Massecuite cooled as follows.—1st massecuite in 12 hours; 2nd in 4 hours; 3rd in 5 days; 4th in 20 days. Centrifugals 1st and 2nd massecuite at about 37 degrees C; 3rd and 4th cold. Massecuite in cars dumped by hand dumper into mixer in reservoir. Massecuite cars raised to upper floor by elevator. Battery of 8 overhead pulley Weston centrifugals, 30 inch type. Revolutions per minute 1200. All sugars worked in same battery of centrifugals. Sugar from centrifugals discharged from below on to apron. Time for centrifugalling massecuite—1st sugar 3 minutes; 2nd sugar 7; 3rd sugar 11; 4th sugar 17. Recovery of sugar over weight of massecuite—1st sugar 63; 2nd sugar 52; 3rd sugar 35; 4th sugar 28. Sugars dried on floor. Polarization of sugars—1st sugar 97.80 to 98; 2nd sugar 93 to 94; 3rd sugar 89 to 91; 4th sugar 87 to 89. Rendiment of sugars over weight of cane—1st sugar 8.11; 2nd sugar 1.97; 3rd sugar .60; 4th sugar .25. Average rendiment of sugar over weight of cane 10.94. Sacks hold 225 lbs. (Eng). Make up mostos at 7 Beaumè; reduced to  $1\frac{1}{2}$ .

Ten boilers—two tubular, eight old type. Excess of fuel; uses only 50 to 60 % of bagasse. Bagasse dried and fed by hand.

Irrigates cane once in three or four weeks. Uses guano, lime, ashes, filter-press-cake, gypsum, sulphate of potash, nitrate of soda; guano is chiefly used. Over 7000 acres now in cane. Estate situated in middle of the valley.

170 men employed in factory during 24 hours. 16 men unload cane at the conductor.

#### FACTORY No. 4.

Some factories make what is called "white sugar" which is merely

the 1st sugar washed. It is sold for local consumption chiefly and brings a good price. This factory makes some white sugar which causes a considerable loss of commercial 1st sugar.

One three roller mill. Double-bottom copper defecators. Does not filter either juice or deposits. Density of juice about 18 to 19 Brix. Extraction of juice over weight of cane 55 to 57. Rendiment of sugar over that indicated in juice 66 to 72. Rendiment of sugar over weight of cane 5.6 to 6.5. Rendiment of 1st white sugar over massecuite 49.

FACTORY No. 5      [*Ingenio Central de Cartavio.*]

The Hacienda Cartavio grinds its cane at the Ingenio Central de Cartavio, a central factory. It differs somewhat from most of the other Peruvian factories.

Two crushing plants each having its own cane conductor. Each plant has a dry double crushing set of mills. Cylinders  $32 \times 66$ . Mills fitted with hydraulic pressure apparatus. Automatic bagasse carrier. Bagasse fed direct to furnaces by hand; also dried and fed by hand. Juice heater is able to heat juice to 220 F. After leaving juice heater juice passes into battery of 15 defecators or subsiding tanks, of 800 Imp. gallons capacity each. The entire series of defecators are connected by partitions forming a continuous battery. Juice is limed with milk of lime 18 to 28 lbs. per defecator. Defecators are not fitted with steam pipes. Requires  $1\frac{1}{2}$  to 2 hours to defecate and settle. Juice is then drawn off to clarifiers fitted with steam coils. Juice is not filtered. Deposits are filtered. One quadruple effect evaporating apparatus. Two iron pans.

Massecuite containers are buckets holding about 275 lbs. Hole in bottom of bucket, stopped by plug, for air pressure when discharging massecuite to pug mill. Pug mill situated below surface of main floor. Massecuite carried up by elevator to centrifugal reservoir. Water added to massecuite in pug mill to facilitate work of elevator. 16 overhead pulley centrifugals in batteries of ten and six. Makes 1st 2nd 3rd sugars, and is fitted to make alcohol.

At times there is a scarcity of bagasse for fuel.

## UTILIZATION OF BY-PRODUCTS.

Waste molasses from the sugar factory contains a good proportion of sucrose and reducing sugars, besides other organic materials, and ash, as is shown by the analysis of 3rd molasses. The sucrose and reducing sugars together make up about 50 % of it. The customary disposition of this waste molasses is to use it in making alcohol. Even when alcohol is made there is a residue of some value; but when alcohol is not made, the disposal of waste molasses becomes a question of considerable importance.

While factory control in some countries has been reduced to a fine system particularly in tracing the losses and in handling the first products to get the greatest amount of sugar out of the cane, little has been done towards pointing out satisfactory ways of utilizing waste molasses other than in making alcohol, and, of late years, making it into stock food. \*

Efforts have been made to burn the molasses with the bagasse to secure the potash in its ash for fertilizer. If the potash in an available condition could be obtained by this method, the process would be a good one; but it is doubtful whether all the potash could be obtained in an available form on account of the high heat which might either volatilize a part of it, or fuse it with the silica contained in the bagasse ashes, which would make a slag of very little account.

Some estates run the waste molasses directly on to the soils in the irrigation waters. It has been found that on soils containing only a fair amount of lime, irrigating water containing 1% molasses produced no immediate deteriorating effects on the cane. Many of the calcareous soils of Peru could stand a greater percentage for a short period at least, since the acids in the molasses produced by fermentation would be partly neutralized by the lime and other compounds. One danger in putting much molasses on soils containing white alkali is that it might have a tendency to produce black alkali. It may be interesting to mention that at Cartavio, the discharged waters from

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\* In 1899, we made experiments with the idea of utilizing waste molasses and succeeded in using it in making calcium carbide for acetylene gas; when burned, the gas gave the characteristic acetylene flame. The experiment was carried on at that time with the hope that satisfactory acetylene motors might be constructed for use in pumping water. In this way the waste molasses would be disposed of on the estate. The refuse from the exhausted carbide would have some fertilizing value,

the factory sometimes containing not only the fermented mostos from the still but waste molasses as well, have been used for irrigating cane. The water is actually sour but still the cane so irrigated does fairly well, the last crop giving 55.4 tons per acre (plant cane). Fortunately, this soil is well supplied with lime, a good proportion of which is in the form of carbonate.

Another way of utilizing waste molasses is to make a large underground compost of cane leaves and molasses, or exhausted mostos. After thorough decomposition this would have considerable fertilizing value. It was tried experimentally at Cartavio; after two months the leaves were partly decomposed; six or eight months would probably effect a thorough decomposition if the compost were kept moist.

Another line of investigation would be the study of the products of the destructive distillation of molasses. Inflammable gases produced by this process have been satisfactorily burned in the ordinary Bunsen burner.

There are a number of ways that the exhausted mostos might be utilized. No potash is lost by using molasses for alcohol as the potash remains in the distilled mostos; besides this potash there will be some phosphoric acid and a little nitrogen. If, then, the distilled mostos is run on a field that is not in cane, and allowed to remain for some time and turned under, a good deal of benefit will be derived, particularly if there is much lime in the soil.

Experiments made here have shown that a mixture can be made of mostos with filter-press-cake which, if left standing long enough to permit evaporation, will produce a comparatively dry material containing 3.2 % potash, and 4.3 % phosphoric acid. A mixture was also made of mostos, filter-press-cake and ashes, and dried.

The value of any method for the disposal of these waste materials will depend, of course, on its practical utility.

## FIELD AND FACTORY CONTROL.

The data derived from a perfect Control for an estate would show the condition of the soils, the condition of the cane, the work in the field, the condition of the factory, the work done on the cane by the factory, and the financial condition of the estate; so that at the end of the year or other required period, the status of every department of the organization could be known, from what it costs to deliver a ton of sugar to its destination to what fertilizing elements are needed for the soil. The reports from the factory, the reports from the laboratory, the accounts from the office, would all go to make it up.

Even under the best conditions, it would require a number of years to put such a full control into perfect operation, and there are probably few estates that would care to support the necessary corp of workers.

There is, however, a very practical and satisfactory Field and Factory Control that most estates could establish. After sifting the mass of data that could be furnished if labor were sufficient, the accompanying Control Chart (filled out for the sake of illustration) represents the data that has been found to be best adapted to conditions at Hacienda Cartavio. For other estates, or in other countries, modifications would in all probability be necessary.

The value of such a Control is that it should lead to an intelligent understanding of the conditions of the soil, the behavior of the cane upon the soil, the quality of cane grown, the work of the factory upon the cane, and the influences that have modified these. By the careful consideration and comparison of a series of such reports, the planter should be able to more judiciously direct the work of the field and factory.

## TAKING SAMPLES OF SOIL FOR CONTROL WORK.

As many of the deductions concerning the character and condition of a soil are based upon the chemical and mechanical analysis of a small sample of that soil, it is important that the sample shall be fairly representative of the entire area to be considered; otherwise the results may be incorrect and misleading. The chief requisite is to carefully examine the whole area in order to determine its general character, and then to take such a sample as will best represent it. A single clod picked up at random, a sample taken from a water-washed knoll, or from a strongly alkali spot, or from a site where animals have pastured, or from a bog, would probably fail to represent the soil of the entire area.

Samples of soil for Control work must be taken with even greater accuracy than for the "general" analysis to determine its constituents, since the object is to find out the effects of Cropping on the soil, such as the amount of elements removed by the crop, approximate amount of elements in the soil for the following crops, influence of irrigation, cultivation, or fertilizers.

To secure samples of soil from crop to crop that will represent as nearly as possible the very same soil, samples for the soil Control at Cartavio are taken in the following way:

The Cartavio estate is divided into sections. Each section is divided into cuartels or fields as nearly rectangular as the boundaries will allow. From a selected corner of the cuartel, a given number of paces are stepped off at right angles to the cane rows; from this point, a given number of paces are stepped off parallel to the rows; here the sample is taken. For example, in the accompanying chart of Section 6, the sample of soil from cuartel 4 would be taken at A, which is the point, say, 80 paces along the edge of the cuartel at right angles to the rows, and 80 paces within the cuartel.

The sample is taken at a depth of from twelve to fourteen inches and according to Standard methods (Hilgard's or the Official Method), first removing all foreign material from the surface soil. The earth is put in a bag that will not lint. In this same way, samples are taken from each of the cuartels in the section.

In the laboratory the samples are air-dried separately. Exactly the same weights of earth are taken from each sample and thoroughly mixed together and bottled for use for Control analysis.

In order to re-locate the place of sample, a chart similar to that

for Section 6 is made for each section, and the number of pieces each way for each cuartel is recorded. It is pasted on the soil bottle or filed away.

SOIL SAMPLING CHART FOR SECTION No. 6.

1	3	5	7
2	4 80 ■.....80 A	6	8

## COMPARATIVE DATA.

It is not only interesting but profitable to have data relative to the cane sugar industry from different parts of the sugar growing world. The data given here has been gathered from personal letters and reliable publications, and although by no means full or complete, is sufficiently representative to permit of some comparison. \*

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\* **NECESSITY OF UNIFORM METHODS OF REPORTING RESULTS.** Even with abundant data comparison is not always easy since different haciendas and different countries may not adopt the same methods of reporting. For example,—the amount of sugar obtained from cane may be given in terms of No. of tons of cane per ton of sugar, or, rendiment  $\%$  over weight of cane, or, No. of lbs. of sugar per ton of cane, or, No. of kilos of sugar per kilos of cane.

A person accustomed to but one of these terms for expressing the amount of sugar obtained from cane, would find comparisons difficult, and the confusion would be increased if it were not known whether the tons were metric, English or Spanish,

An International Sugar Growers' Congress could not intelligently discuss reports presented in such varying terms; they would have to be sifted down to a common basis. It is questioned whether a plantation owner in the United States would easily grasp the idea of the yield of cane if given in terms of quintals and fanagadas; and an estate owner in Peru might find it hard to learn what was being done in Louisiana by reading of "so many tons per acre."

The Metric system seems to be the most universal and rational, and it is gradually becoming the standard system in Peru.

# ANALYSES OF SOME SOILS OF SUGAR GROWING COUNTRIES.

	LOUISIANA.	EGYPT. *	JAMAICA. *	HAWAII. *	CUBA. * ††	
	%	%	%	%	%	
Insoluble Matter.....	88.720	52.83	48.45	35.150	27.870	
Potash (K <sub>2</sub> O) .....	.092	1.33	.11	.286	.272	
Soda (Na <sub>2</sub> O).....	.158	.95	.70	.355	.391	
Lime (Ca O).....	.394	5.84	.99	.390	.294	
Magnesia (Mg O) .....	.087	3.14	.29	.802	.610	
Manganese Oxide (Mn O).....		.36	.09	.187	.150	
Ferric Oxide (Fe <sub>2</sub> O <sub>3</sub> ).....	1.12	10.26	6.72	19.980	21.810	
Alumina (Al <sub>2</sub> O <sub>3</sub> ) .....		16.19	13.80	16.155	13.621	
Phosphorus Pentoxide (P <sub>2</sub> O <sub>5</sub> ) .....	.068	.38	.10	.396	.470	
Sulphur Trioxide (S O <sub>3</sub> ) .....	.028	.30	.30	.234	.157	
Carbon dioxide (CO <sub>2</sub> ).....		2.37	1.05	.290	.030	
Water and Organic matter ....	2.96	3.16	15.36	6.03	trace	
Chlorine .....		.09	.51	trace	trace	
Nitrogen .....	.097	.043	.31	.05	.256	
Moisture.....			12.25	18.72	9.031	
					12.290	
	QUEENS- LAND.	NEAR LIMA. †	NEAR SU- PE. †	UPPER CHICA- MA VALLEY †	MIDDLE CHICA- MA VALLEY. †	LOWER † CHICAMA.
	%	%	%	%	%	%
Insoluble Matter .....			77.00			68.87
Potash (K <sub>2</sub> O) .....	.189	.17	.37	.191	.152	.38
Lime (Ca O) .....	.156	2.44	1.53	1.64	3.276	2.60
Magnesia (Mg O) .....					.919	1.17
Phosphorus Pentoxide (P <sub>2</sub> O <sub>5</sub> ) .....	.242	.236	.23	.158	.210	.26
Water and Organic matter...			5.96			7.57
Nitrogen.....	.202	.122	.112	.114	.124	.13

\* A few factors of the original analysis have been omitted. † Peru. †† Unmanured and manured tobacco soil.

\* A few factors of the original analysis have been omitted.

† Peru.

†† Unmeasured and manured tobacco soil.

Climate exerts even a greater influence on the yield and quality of cane than does soil or methods of cultivation.

A climate essentially tropical with copious rains from which the cane derives its water, and a steamy, sultry atmosphere, produces a cane of fair yield, low sugar, low fibre, and high amount of juice of fair purity.

A climate where the summers are warm but the winters are cool, so cool that the cane is in danger of being injured by frost, will produce a cane of low yield, low sugar, low fibre, and high amount of juice of low purity.

The climate that seems to be conducive to heavy yields of cane, and of canes containing high sugar, high fibre, and a juice of high sugar and good purity, is one which is comparatively warm throughout the year, and where the cane derives its water chiefly or wholly from irrigation. Such are the conditions on the dry sides of the Hawaiian Islands, and it is there that the highest production of cane is found. Peru is another country having such conditions. While in many of the sugar districts of Peru the climate may not be as warm as in some of the dry sections of Hawaii, there are districts that are quite as warm. Peru belongs to the heavy producing class, and although it requires somewhat longer for cane to mature in most of the districts here than in some other sugar countries, four or five profitable cuts can be made.

Temperature records taken in a given locality by different methods of observation may give radically different results. The thermometer is supposed to be kept in the shade, but the shaded spot may be so protected as to prevent a free circulation of air and the temperature from a thermometer so placed would not tally with that recorded by a thermometer placed where there was a free circulation of air. If temperature records are to have value for comparison, they must be taken according to The Standard Regulations.

## TEMPERATURE RECORDS FROM

	HAWAII. *			CUBA.				
	Mean Max.	Mean Min.	Mean	Mean Max.	Mean Min.	Mean	Highest	Lowest
January.....	24.4	20.5	22.2	22.7	16.6	19.4	28.3	10.5
February.....	23.3	18.3	20.5	25.5	18.8	21.6	28.8	14.4
March.....	25.5	20.5	23.3	27.2	18.8	22.7	30.0	13.8
April.....	26.6	20.5	23.8	27.2	20.0	23.8	31.6	16.1
May.....	28.3	21.6	25.0	28.8	21.6	25.5	31.1	20.0
June.....	28.8	21.1	25.0	30.0	22.7	26.6	31.6	21.6
July.....	29.4	22.7	26.1	31.1	23.8	27.7	32.7	22.2
August.....	29.4	23.3	26.6	30.0	22.7	26.6	31.1	21.1
September.....	28.8	22.2	25.5	29.4	23.3	26.6	31.1	21.6
October.....	27.7	21.6	24.4	27.7	22.2	25.0	30.5	16.1
November.....	26.1	21.1	23.8	26.1	20.0	22.7	30.0	15.0
December ..	24.4	20.0	22.2	25.0	19.4	22.2	28.8	15.5

	HDA. LURIFICO. (Perú) **					JAVA.		
	Mean Max.	Mean Min.	Mean	Highest	Lowest	Mean Max.	Mean Min.	Mean
January.....	30.5	20.5	25.5	32.7	17.7	30.0	22.5	26.2
February.....	31.1	21.1	26.1	32.7	18.3	29.1	22.4	25.3
March.....	30.0	20.0	25.0	31.6	18.3	29.8	22.2	27.2
April.....	28.3	18.3	23.3	30.5	17.2	30.7	22.5	26.1
May.....	27.2	17.7	22.7	29.4	15.0	31.0	22.1	26.5
June.....	25.0	16.6	21.1	27.2	15.0	30.1	21.9	26.1
July.....	24.4	17.7	21.1	26.6	14.4	30.3	20.7	25.5
August.....	25.5	17.7	21.1	27.2	16.6	30.6	21.3	26.0
September.....	26.1	16.6	21.1	28.3	15.0	31.4	21.5	26.5
October.....	26.6	16.1	21.6	28.8	13.3	31.9	23.1	27.1
November.....	27.7	15.5	21.6	28.8	14.4	31.9	23.2	26.5
December....	29.4	18.3	23.8	32.2	15.5	29.2	21.4	26.3

\* Highest 32; lowest 14.

\*\* Upper Pacasmayo Valley.

## SOME CANE-SUGAR COUNTRIES. (Centigrade)

	CARTAVIO. (PERU)					BRAZIL.		
	Mean Max	Mean Min.	Mean	Highest	Lowest	Max.	Min.	Mean
January.. .....	26.6	20.4	23.3	27.7	18.8	35.9	22.3	28.5
February.....	27.5	21.5	24.4	28.8	20.0	34.1	21.5	27.0
March.....	28.0	21.4	21.1	29.4	18.8	33.8	22.0	27.0
April.....	26.1	19.5	22.7	28.8	17.7	32.4	21.2	26.4
May.....	24.0	18.4	21.1	25.5	16.6	32.0	20.6	26.4
June.....	23.1	18.1	20.5	24.4	16.6	31.9	19.7	25.6
July ... ..	21.2	17.0	19.1	23.3	14.4	32.8	19.7	26.0
August.....	21.7	16.6	19.2	23.3	15.0	33.8	19.9	26.6
September .....	22.0	15.8	18.9	23.3	13.8	35.3	21.8	27.8
October .....	23.2	15.6	19.4	25.0	15.0	35.9	22.7	28.4
November. ....	23.9	15.7	19.8	25.0	12.7	36.0	23.1	28.5
December.....	25.0	17.2	21.1	26.6	14.4	35.9	22.4	28.6

	PORTO RICO.	LOUISIANA.			EGYPT.	LIMA. (Perú)		
	Mean.	Max.	Min.	Mean	Mean	Max.	Min.	Mean
January.....	22.7	25.0	3.3	10.0	12.7	31.3	16.4	23.6
February.....	22.7	22.0	9.4	6.6	15.0	32.2	16.0	24.4
March.....	22.7	27.2	1.1	16.1	17.2	31.7	16.6	23.9
April.....	23.8	30.7	7.7	19.4	21.1	29.4	16.7	22.6
May.....	25.0	32.2	11.1	23.8	23.8	28.6	13.7	20.2
June.....	25.5	35.0	20.0	27.2	27.2	24.8	11.0	18.6
July.....	25.5	36.6	21.6	27.7	28.8	25.4	11.0	18.6
August.....	25.4	36.6	22.2	28.3	27.7	25.4	13.2	17.9
September .....	26.1	33.8	11.1	26.7	25.0	23.5	14.0	17.2
October .....	25.0	30.0	8.3	30.5	23.3	26.0	12.5	18.5
November.....	25.0	27.7	16.7	15.0	18.3	25.6	13.0	19.1
December.....	23.8	23.3	3.8	10.5	14.4	27.7	13.8	20.9

# DATA CONCERNING SOME CANES AND JUICES FROM SOME SUGAR-GROWING COUNTRIES.

COUNTRY.	% Sucrose in cane	% Fibre in cane	% Sucrose in juice	Brix	Purity	% Glucose
Hawaii.	14.3	11.8	17.3	19.8	87.0	Average of from 30 to 50-70 tons of cane per acre depending on how cane receives its water. The high yields are produced in the irrigated districts, where on certain estates an average of 80 tons of cane per acre is grown. Cane cut in about 18 mos.
	14.7	12.8	17.3	18.9	91.6	
	14.9	12.2	16.9	18.3	92.5	
	15.5	14.6	18.8	21.3	88.7	
Java.	12.5	11.9	15.0	17.5	85.3	Average of 30-40 tons of cane per acre.
	10.7	11.3	12.6	15.7	80.7	
	14.6	11.5	17.3	19.2	90.0	
	15.1	10.8	17.7	19.8	89.4	
Egypt.	12.8		14.9	17.7	84.	Average of 15-22 tons of cane per acre; 9 tons for 2nd cut. Possible to get 32 tons for 1st cut; 20 tons for 2nd cut. Makes 2 cuts. Cane cut in about 11 mos.
	13.2		15.9	17.8	89.7	
	10.8		12.8	16.0	80.5	
	14.2		16.8	19.6	85.9	
Louisiana.			12.7	15.9	78.1	Average of 22 tons of cane per acre. As high as 60 tons of cane have been grown under very favorable conditions. Canes cut in about 9 mos, on account of frost. Makes about 3 cuts.
			15.1	17.8	85.9	
			12.7	15.6	81.1	

COUNTRY.	% Sucrose in cane	% Fibre in cane	% Sucrose in juice	Brix	Purity	% Glucose
Cuba. (very little data available)			15.0	19.1	84.	
Queenland	14.5	10.7	16.1	17.5	93.5	.65
	15.6	12.8	17.9	19.5	91.5	.66
	12.7	10.4	14.1	15.8	89.8	.85
Trinidad.	13.1		15.4		86.0	1.51
	14.7		16.5		91.5	.91
	12.9		14.5		86.7	1.52
Perú.*	15.9	15.5	18.5	20.5	90.4	.46
	14.6	14.3	17.1	19.3	88.5	.54
	15.2	14.2	17.7	19.1	92.3	.46
	13.9	15.5	16.5	18.6	88.7	.65
	16.4	15.9	19.6	21.1	91.4	.35

In 1903, an average of 21 tons of cane per acre grown on good land.

Average yield in 1903, 13.65 tons of cane per acre.  
Possible to double yield.  
Cane cut in 11-13 mos.

Average yield 30-40 tons of cane per acre.  
Average yield could be raised to over 50 tons.  
Canes cut in 18-23 mos.  
Makes 4-5 cuts.

\* Sucrose in juice is sometimes as high as 21 % and Brix 22.

In judging of the efficiency of the work of any factory, judgement must be based chiefly upon the amount of sucrose contained in the cane to be worked upon. A factory dealing with canes of low sugar content cannot be expected to secure as much sugar from a given weight of cane as though the canes had a high sugar content.

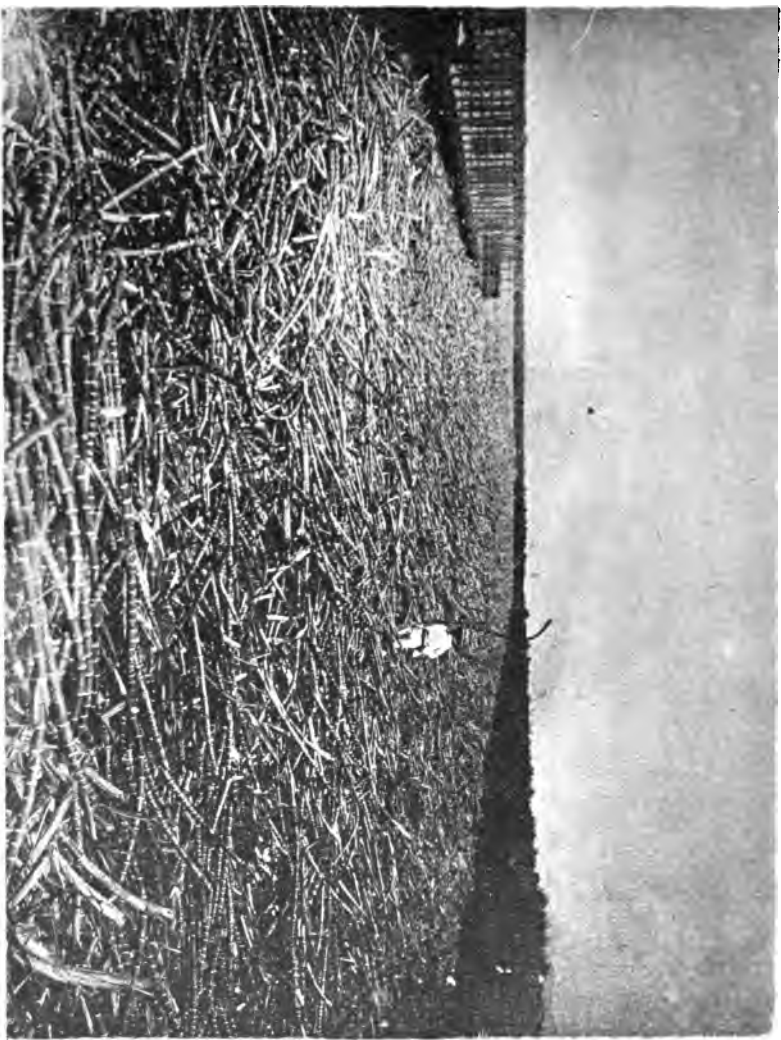
Some data respecting the class of cane ground, the work of the mills upon that cane, and the total rendiment of sucrose, has been selected from Java and Hawaii two of the most progressive cane sugar countries.

It is very difficult to formulate factory data from different countries for comparison, because of the lack of uniformity in the terms and methods of reporting. The data below has been reduced to common terms, and, it is believed, faithfully represents the original figures.

	Sucrose in cane %	Fibre in cane %	Sucrose in juice on 100 cane. %	Extraction of sucrose in juice on 100 sucrose in cane. %	Rendiment of sucrose on 100 cane. %	Rendiment of commercial sugar on 100 cane. %	Total loss of sucrose on 100 cane. %
Hawaii.	15.49	12.17	14.37	92.79	13.38		2.11
	14.17	11.50	13.55	95.65	12.56		1.61
	13.61	11.38	12.74	93.61	11.91		1.70
	14.03	10.93	12.89	91.92	11.93		2.10
	15.05	11.44	14.39	95.62	13.25		1.80
Java.	13.85	10.33	12.84	92.71	12.00	12.22	1.85
	15.18	10.84	14.05	92.56	12.96	13.02	2.22
	14.68	11.51	13.39	91.21	12.34	12.40	2.34
	12.54	10.94	11.57	92.26	10.69	11.07	1.85
	12.93	10.68	12.04	93.12	10.95	11.03	1.95
	11.90	11.19	10.72	90.09	9.76	9.81	2.14
Peru. *	14.44	14.60	11.57	80.18	9.66	10.04	4.78
	15.62	16.27	12.74	81.59	9.78	10.20	5.84
	14.72	13.88	11.72	79.62	8.61	9.05	6.11
	16.22	16.13	12.74	78.57	9.47	9.70	6.25
	15.39	14.80	12.14	78.89	9.51	9.99	5.88
	16.45	15.95	12.89	78.36	10.95	11.25	5.50
	13.91	15.54	10.86	78.13	8.08	8.42	5.83

\* Factory No. 3 described in Manufacture records a rendiment of 12 % commercial sugar on 100 of cane, making 1, 2, 3 & 4 sugars.





AN 85-ACRE FIELD THAT YIELDED 79.8 LONG TONS OF CANE PER ACRE. (Artavio.)

# **PARTICULAR DATA CONCERNING HACIENDA CARTAVIO.**

Cartavio is a long and narrow estate; not including its recently acquired properties, it is about 10 miles long and 2 miles wide at the widest part narrowing down to a mile or less.

There is a marked variation in the soils, even between those of adjacent Sections as will be seen by examining the analyses of soils and locating the Sections on the map. There is also a noticeable difference in the amounts of the most important soil elements. To show this at a glance, the percentages of potash, phosphoric acid, lime and nitrogen, are here given from Sections taken in a line lengthwise of the estate.

SECTION	23	13	14	7	5	4	4 B	1 A
Potash.....	.32	.47	.16	.17	.19	.45	.20	.35
Lime.....	3.88	2.94	1.90	1.75	3.05	5.90	1.82	2.24
Phosphoric acid...	.18	.21	.25	.15	.19	.27	.16	.25
Nitrogen.....	.19	.11	.12	.13	.14	.13	.07	.07

Another interesting feature of these soils is the variation in their physical condition; some are loose and sandy while others are stiff. The improvement of the physical condition of some of them is quite as important as supplying potash, phosphoric acid and nitrogen. Section 10 has a soil whose physical condition is good but is not particularly rich in plant food elements; Section 4, on the other hand, has a stiff, cracky soil that is difficult to work, but its chemical analysis shows it to be high in total plant food elements. Section 10 gave 7 cuts of cane, the last cut yielding 43.04 tons of cane per acre; Section 4 allowed of but 4 cuts, the last giving only 16.62 tons per acre. Section 4 has the richer soil but it needs physical rectification; the addition of large quantities of sand would doubtless increase its productiveness.

Although some of the soils have been under cultivation for a number of years, their production of cane is increasing, and with continued proper treatment they will improve for a good many years to come.

The yield of cane for the past three years has been between 45 and

50 long tons per acre; this average is pulled down by old last-cut cane that has been growing for about eight years and which was not fertilized in its early period of growth. The average yield can be raised to 60 tons per acre.

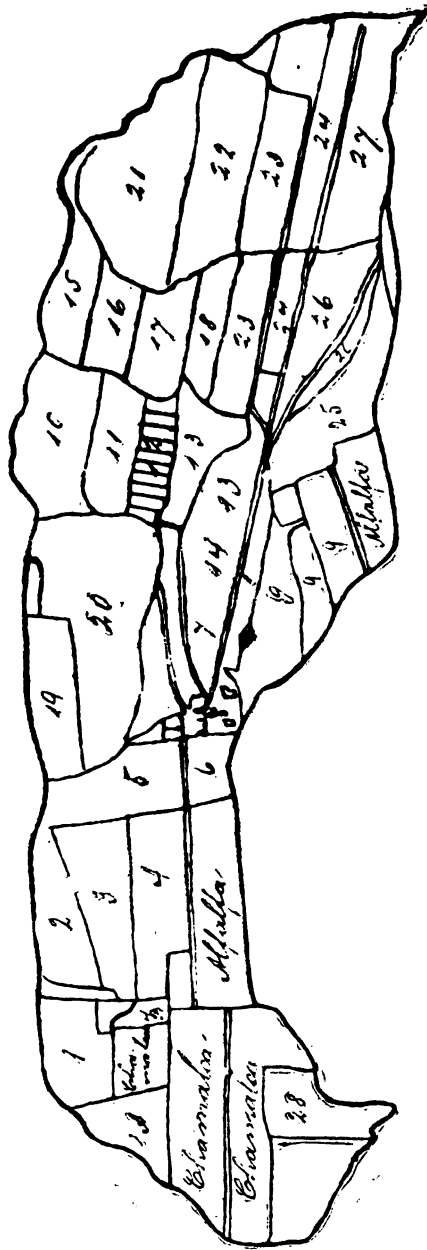
By good cultivation and the use of fertilizer, the ratoon crop has in some cases given more cane than the plant. Cane on some Sections has been cut 7 times with good results. This means that the roots have remained in the soil for at least twelve years. 4 cuts are usually made.

The highest yield of cane obtained at Cartavio, and probably in Peru, was 79.8 long tons per acre from a field of about 85 acres (ratoon crop). This cane contained 15.24% sucrose which would mean about 12 tons of sugar grown per acre; of this, 7.4 tons of commercial sugar were recovered in bags.

The average yield of sugar for Cartavio at present is about 4.5 long tons per acre. With the most up-to-date factory equipment the average would be raised considerably. It is encouraging to observe that the out-put of sugar has been raised 2 long tons during the past ten years; or, the same acreage gives 4000 long tons more sugar now than it did ten years ago.

The data from the Control Charts gives a pretty clear record of the amount and quality of cane grown per Section, and the work of the factory upon it.





APPROXIMATE OUTLINES OF SECTIONS OF HACIENDA CARTAVIO.  
(Section 12 showing cuarteles.)

## ANALYSES OF SOILS OF HACIENDA CARTAVIO.

SECTION	1	1 A	(hamal- ta)	2	3	4	4 B	5	6	7
Fine earth.....	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Insoluble Matter .....	58.28	79.58	72.80	60.68	65.12	59.20	73.91	55.56	64.00	80.31
Soluble Silica.....	14.56			14.42	9.30	8.20	9.23	12.72	11.20	
Potash (K <sub>2</sub> O) .....	.52	.355	.237	.40	.389	.45	.203	.193	.45	.171
Soda (Na <sub>2</sub> O) .....	.27			.22	.25	.27	.234	.269	.22	
Lime (Ca O) .....	2.75	2.24	2.99	2.50	3.20	5.90	1.82	3.05	3.36	1.75
Magnesia (Mg O) .....	1.29			.60	.88	1.50	.23	1.00	.98	.43
Manganese Oxide (Mn O) .....	.60			trace	.07	.10	trace	.15	trace	
Ferric Oxide (Fe <sub>2</sub> O <sub>3</sub> ) .....	5.20	9.20	7.70	5.04	5.70	5.60	5.67	4.47	5.40	6.85
Alumina (Al <sub>2</sub> O <sub>3</sub> ) .....	5.61			7.42	5.19	3.86	3.41	4.25	5.14	
Phosphorus Pentoxide (P <sub>2</sub> O <sub>5</sub> ) .....	.25	.25	.180	.26	.32	.290	.162	.192	.285	.150
Sulphur Trioxide (SO <sub>3</sub> ) .....	.12			.10	.17	.27	.05	.069	.18	
Carbon dioxide (C O <sub>2</sub> ) .....	1.92	1.28	1.80	1.31	2.35	3.59	.934	1.45	2.50	
Water and Organic matter.....	8.50	5.70	6.67	6.70	7.58	10.35	4.35	6.80	6.80	7.00
Nitrogen in Soil.....	.091	.077	.115	.108	.133	.135	.076	.140	.155	.130
Humus.....	1.10			1.00	1.25	1.84	.85	.96	1.44	
Humus Ash.....	.88			.80	1.22	1.80		1.32	1.20	
Hygroscopic Moisture.....	4.46			5.80	6.20	7.15	4.50	5.50	7.60	
Moisture.....	1.40	1.70	2.60	1.50	1.52	2.10	1.50	1.85	4.88	
Soluble in Citric acid (1).....						.0064				
Phosphorus Pentoxide.....	.00384	.0019	.0102	.0064			.0020	.0038	.0076	.0050
Potash .....	.00918	.0058	.0146	.0073				.0140	.0085	
Soluble in Citric acid (2) .....										
Phosphorus Pentoxide .....	.0435	.0140	.0152	.0367	.063	.600	.0106	.039	.0452	.0160
Potash .....	.0124	.0090		.0098	.0258	.0231	.0059	.025	.0117	.0076

(1) Soluble in citric acid sufficient to neutralize sol.

(2) " " " " plus 1 % citric acid.



SECTION	18	19	20	21	22	23	24	25	26	27
Fine earth .....	100.00	100.00	100.00	100.00	100.01	100.00	100.00	100.00	100.00	100.00
Insoluble Matter .....	58.44	71.03	61.72	61.30	51.41	61.60	66.60	79.50	49.22	59.19
Soluble Silica .....	10.82	7.71	16.40	10.02	12.70	9.00	8.80	5.90	15.10	18.17
Potash ( $K_2O$ ) .....	.42	.60	.39	.24	.20	.32	.24	.23	.39	.38
Soda ( $Na_2O$ ) .....	.30	.41	.38	.20	.53	.43	.20	.13	.32	.83
Lime ( $CaO$ ) .....	4.30	2.00	1.55	3.30	6.75	3.88	2.87	.65	5.90	2.14
Magnesia ( $MgO$ ) .....	1.27	.95	.52	1.53	1.56	.65	.84	.46	2.57	.82
Manganese Oxide ( $MnO$ ) .....	trace	.10	trace	trace	.09	trace	.40	trace	trace	.08
Ferric Oxide ( $Fe_2O_3$ ) .....	6.72	4.80	4.80	5.90	5.10	6.40	5.20	4.80	4.00	6.12
Alumina ( $Al_2O_3$ ) .....	6.05	4.67	4.79	6.14	2.42	5.11	4.98	3.14	7.50	4.62
Phosphorus Pentoxide ( $P_2O_5$ ) .....	.20	.29	.18	.24	.19	.18	.23	.18	.311	.22
Sulphur Trioxide ( $SO_3$ ) .....	.15	.40	.19	.10	.88	.14	.12	.06	.30	.08
Carbon dioxide ( $CO$ ) .....	3.80	1.33	.66	2.00	2.60	2.20	2.00	.20	3.08	1.34
Water and Organic matter .....	7.37	5.41	8.76	8.50	15.20	10.60	7.60	4.60	11.10	5.91
Nitrogen in Soil .....	.116	.095	.182	.119	.189	.187	.125	.084	.245	.107
Humus .....	1.40	1.12	1.50	1.14	1.59	1.25	1.20	.76	1.77	1.05
Humus Ash .....	1.32	.94	1.22	.95	1.74	2.30	1.02	.78	1.70	1.30
Hygroscopic Moisture .....	7.80	8.60	6.04	6.40	8.10	9.45	6.82	3.95	10.50	6.30
Moisture .....	1.80	1.50	3.10	2.04		3.60	1.80	2.00	7.60	2.04
Soluble in Citric acid (1) .....										
Phosphorus Pentoxide .....	.0150	.0034	.0034	.0078	.0110	.0042		.0074	.0140	.0068
Potash .....	.0055	.0065		.0028	.0054	.0026		.0030	.0052	.0079
Soluble in Citric acid (2) .....										
Phosphorus Pentoxide .....	.025	.0081	.0081	.0382		.0277		.0190	.0350	.0273
Potash .....	.019	.0155	.0155	.0050		.0056		.0085	.030	.0101

**DATA SELECTED FROM CONTROL CHARTS.**  
(SHOWING SECTIONS CUT DURING 1905.)

SECTION.	Sucrose in cane.	Fibre in cane.	Moisture in cane.	Sucrose in juice.	Glucose in juice.	Brix of juice.	Purity of juice.	Moisture in Bagasse. 1st Mill. 2nd Mill.	Moisture in F. P. C.	Sucrose in F. P. C.	Extraction of juice on 100 cane.	Extraction of sucrose in cane obtained in juice.	Extraction of sucrose on 100 sucrose in juice.	Ash in juice.	
22	14.7	13.8	68.0	17.1	.91	19.9	85.5	43	47	57.5	10.7	68.8	79.6	76.0	.34
22	15.4	15.6	67.1	18.4	.61	20.7	88.8	43	45	58.1	12.1	67.1	79.6	84.9	.43
14	15.0	15.4	66.6	17.8	1.01	20.6	86.3	45	51	56.8	12.2	61.7	73.0	81.1	.37
4	16.1	16.5	65.1	19.3	.95	22.3	86.6	44	47	55.2	13.9	53.6	65.6	72.4	.37
Chamalca	14.6	14.3	67.4	17.1	.54	19.4	88.5	44	47	57.7	12.2	66.4	77.9	81.0	.54
20	15.0	14.8	66.2	17.9	.57	21.2	84.3	45	54	56.	11.6	56.7	68.8	80.4	.37
20	13.9	15.5	67.4	16.5	.65	18.6	88.7	44	46	57.5	12.1	67.1	77.1	78.1	.67
1 A	14.9	14.6	67.6	17.4	.52	19.7	88.3	44	46	57.7	12.4	66.2	78.2	82.5	.61
4 B	15.4	14.8	67.8	17.0	.74	19.1	88.5	46	48	57.7	11.7	66.9	78.9	87.1	.62
13	15.1	15.6	67.1	17.9	.59	20.2	88.5	44	46	58.0	11.8	66.9	79.4	83.5	.56
12	15.3	15.8	66.7	18.2	.56	20.5	88.6	44	46	57.5	12.8	67.9	80.7	84.6	.45
15	14.4	14.6	68.0	16.9	.66	19.0	88.9	44	47	57.8	11.9	69.2	80.2	85.8	.42
18	14.3	15.5	67.4	16.9	.62	19.2	87.7	42	45	57.7	12.0	68.6	81.0	87.9	.45
26	15.6	16.3	66.2	18.6	.52	20.7	90.0	44	47	57.6	12.3	66.9	80.1	81.6	.45
6	13.3	15.9	67.0	15.8	.68	18.3	86.0	45	48	57.2	11.6	67.1	79.8	77.9	.56
21	15.4	15.6	67.1	18.4	.61	20.7	88.8	43	45	58.1	12.1	67.1	79.6	84.9	.43
23	15.6	15.7	66.2	18.1	.62	20.9	86.4	43	45	58.8	11.5	66.3	78.9	82.6	.50
24	14.7	15.9	66.6	18.2	.60	20.9	87.3	45	47	57.7	12.9	66.6	79.3	77.9	.58
27	13.9	14.3	68.1	16.4	.67	18.9	86.7	43	46	57.9	11.9	65.0	77.2	88.4	.65

SECTION.	Masseculite No 1.				Recovery of sugar on weight of masseculite.	Molasses No. 3.				Sucrose Accounted For in					Polarization of 1st sugar.
	Sucrose.	Glucose.	Brix.	Purity.		Sucrose.	Glucose.	Brix.	Purity.	Molasses.	F. P. C.	Bagasse.	Bags.	Unknown. *	
22	80.8	3.0	91.8	88	60	34.8	15.9	86.4	40	.95	.24	2.93	8.61	1.99	96.9
22	82.4	4.6	93.2	88	60	31.9	14.9	85.4	37	.42	.34	3.10	10.00	1.31	97.7
14	80.3	2.7	91.7	87	53	36.6	17.2	86.6	42	1.08	.30	4.31	8.31	1.03	97.1
4	79.9	3.9	92.6	86	54	38.	20.4	84.9	44	.68	.30	5.45	7.37	2.29	96.4
Chamalca	80.8	2.8	92.4	87	61	36.	15.3	84.8	42	.63	.22	3.24	8.84	1.73	97
20	80.3	2.8	93.6	85	53	35.	19.9	84.8	40	1.41	.30	4.40	8.17	.77	97.4
20	78.8	5.0	93.7	84	56	33.2	15.8	86.5	38	.44	.33	3.12	8.08	1.77	97.3
1 A	81.8	2.4	92.4	88	60	37.4	14.0	86.4	43	.76	.21	3.32	9.14	1.47	97.3
4 B	81.8	3.6	93.9	87	60	36.4	14.7	90.6	40	.88	.21	3.91	9.51	.88	97.7
13	80.8	4.6	94.0	85	61	31.6	13.7	85.4	37	.42	.29	3.08	9.65	1.53	97.1
12	81.7	4.5	93.6	87	61	31.8	15.8	86.3	36	.34	.26	2.98	9.93	1.65	96.8
15	82.4	4.3	93.3	88	61	33.3	14.4	83.8	39	.49	.11	2.72	9.66	1.46	97.6
18	80.8	4.6	93.6	86	61	33.7	15.4	85.8	39	.49	.33	2.80	9.71	.84	97.3
26	81.4	4.5	93.5	87	60	31.4	15.2	86.4	36	.74	.11	3.11	9.78	1.88	97.1
6	80.2	4.4	94.5	84	56	34.1	16.1	86.3	39	.57	.31	2.98	8.76	.52	97.2
21	82.4	4.6	93.2	88	60	31.9	14.9	85.4	37	.42	.34	3.10	10.00	1.31	97.7
23	81.6	4.7	94.4	86	58	30.8	14.7	86.7	35	.82	.32	3.37	8.34	2.51	97.6
24	80.0	4.1	94.4	85	56	35.5	17.5	86.2	41	.73	.33	3.13	8.91	1.71	97.9
27	80.7	4.8	94.7	85	58	34.5	15.9	86.2	40	.85	.33	3.03	8.32	1.20	97.6

\* Losses on floor, in drainage waters, and in material blown up to mostos tank.

SECTION	Speed of mills.				No. of acres in section.	No. of times irrigated.	Age of cane. Months.	No. of cut.	Tons of bagasse per ton of commercial sugar.	Fertilizer applied.	Lbs. of fertilizer applied per acre.	Tons of cane grown per acre.	Tons of sucrose grown per acre.	Tons of commercial sugar recovered per acre.	Rendiment of sugar on 100 cane.	Total loss of sucrose on 100 cane.
	1st mill.	A	B	2nd mill.												
22	23.7	10.4	22.4	10.5	179.		22	3	2.95	Guano	2692	46.5	6.84	4.20	9.05	6.11
22	24.1	11.	24.7	11.1	85.9	9	19	4	3.17			49.7	7.64	5.17	10.41	5.38
14	24.1	10.8	22.4		64.4		23	1		Guano	1804	44.6	6.69	3.87	8.69	6.72
4	22.1	10.8	22.3		214.8	9	23	4	6.01			16.6	2.67	1.28	7.71	8.72
Chamaica	24.6	11.1	24.5	10.8	501.2	13	22	3	3.62	Guano	1984	42.3	6.21	3.92	9.26	5.82
20	25.	11.6	21.6		35.8		21	4	5.02	Guano	2692	28.8	4.34	2.47	8.56	6.88
20	22.5	13.3	21.9	12.2	264.9	12	21	1	3.93	Guano	3114	55.6	7.74	4.68	8.42	5.83
1 A	24.0	11.1	23.3	10.9	143.2	10	20	2	2.53	Guano	2000	60.0	8.94	5.74	9.56	5.76
4 B	24.4	10.5	24.4	11.0	21.5	11	21	4	3.31	Guano	1577	41.7	6.41	4.16	9.99	5.88
13	24.1	10.8	24.1	10.5	85.9	10	21	2	3.27	Guano	2298	53.9	8.18	5.44	10.1	5.52
12	23.8	10.2	22.2	11.1	71.6	14	20	2	3.08	Guano	2350	55.5	8.48	5.77	10.4	5.35
15	24.5	11.	24.	10.9	150.4	9	21	2	3.07	Guano	1696	55.4	8.00	5.56	10.0	4.78
18	23.7	11.	24.4	16.5	71.6	12	21	2	3.10	Guano	3473	70.3	10.1	7.13	10.1	4.64
26	23.8	10.8	24.1	10.5	186.1	8	23	5	3.21			27.7	4.33	2.83	10.2	5.84
6	20.8	18.3	20.2	17.7	35.8	10	20	1	3.59	Guano	2755	55.4	8.16	5.07	9.15	4.58
21	24.1	11.0	24.7	11.1	21.5	5	19	3	3.16	Guano	1651	52.5	8.07	5.46	10.4	5.38
23	22.7	21.0	21.6	19.4	71.6	7	23	3	3.80	Guano	1925	42.3	6.59	3.75	8.60	7.24
24	20.9	18.8	20.9	17.9	71.6	8	23	3	4.23	Guano	1035	66.4	9.78	6.12	9.22	6.05
27	18.3	17.1	16.3	16.2	200.5	7	23	1	3.85	Guano	2457	61.6	8.54	5.43	8.83	5.56

For Sections 22 (2nd), 20 (2nd), 13, 12, 19, 6, 21, 23, 24, and 27, "inversion" has been estimated and deducted from "unknown losses".

In Section 24 read—  
 Sucrose in cane..15.2. Sucrose accounted for in Bags..9.15. Lbs. of fertilizer applied per acre..  
 2035. Tons of sucrose grown per acre..10.1.  
 In Section 6 read—  
 Tons of sucrose grown per acre..7.39. Extraction of sucrose on 100 sucrose in juice..87.9.  
 In Section 23 read—  
 Extraction of sucrose on 100 sucrose in juice..72.6.

## CROP RECORD FOR TEN YEARS.

1 8 9 6 .					1 8 9 7 .				
Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.	Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	1	57.3	162.5	2.84	16	2	143.2	445.0	3.11
3 & 4	5	143.2	95.0	.63	21	4	214.8	420.0	1.91
7	2	71.6	160.1	2.25	5	2	171.8	564.0	3.30
8	2	35.8	122.3	3.48	10	3	214.8	675.3	3.15
10	2	214.8	640.9	2.98	14	3	42.9	71.2	1.69
11	4	143.2	345.5	2.41	17	2	71.6	280.1	3.94
12	2	71.6	131.0	1.84	15	3	171.8	400.5	2.34
13	1	85.9	260.0	3.02	2	1	64.4	335.3	5.23
14	2	43.0	127.2	2.96	22	5	214.8	490.0	2.28
15	2	171.8	461.9	2.68	6	1	257.8	725.0	2.82
17	2	143.2	429.2	2.99	11	5	143.2	300.0	2.10
18	1	35.8	100.0	2.85	Saplan.	1	14.3	62.7	4.47
19 & 20	5	71.6	136.0	1.90	8	3	35.8	92.0	2.62
22	4	358.0	850.5	2.37	7	3	71.6	100.0	1.40
23	3	50.1	96.0	1.92	13	2	85.9	201.0	2.36
24	5	35.8	66.7	1.90	18	2	35.8	82.0	2.34
25	5	71.6	136.0	1.90	1	2	57.3	158.0	2.77
26	6	78.8	149.0	1.91	24	6	25.0	63.7	2.52
27	1	243.4	668.6	2.74	9	1	300.7	793.0	2.64
					27	2	100.0	202.1	2.00

## RECAPITULATION.

No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	422.4	1191.1	2.82
2	751.9	2072.6	2.75
3	50.1	96.0	1.92
4	501.2	1196.0	2.39
5	322.2	433.7	1.35
6	78.8	149.0	1.90
	2126.6	5138.4	

Average out-put ..... 2.42

## RECAPITULATION.

No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	637.2	1916.0	3.00
2	665.6	1932.2	2.90
3	536.9	1339.0	2.50
4	214.8	420.0	1.95
5	358.0	790.0	2.21
6	25.0	63.7	2.52
	2437.5	6460.9	

Average out-put ..... 2.65

1 8 9 8 .					1 8 9 9 .				
Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.	Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
27	2	143.4	283.9	1.98	10	4	71.6	215.2	3.00
24	6	150.4	109.6	.73	15	4	171.8	252.5	1.47
23	6	157.5	43.4	.27	22	6		60.	
16	3	143.2	312.0	2.18	9	2	300.7	435.	1.45
21	4	214.8	360.0	1.67	27	3	243.4	540.	2.22
5	3	171.8	535.6	3.12	7	4	71.6	60.	.84
17	3	71.6	148.0	2.06	8	4	35.8	50.	1.42
2	2	64.4	245.0	3.82	13	3	85.2	150.	1.74
25	1	286.4	800.0	2.80	18	3	35.8	43.	1.22
26	1	329.4	800.0	2.42	19	1	21.5	46.	2.19
6	2	257.8	271.9	1.05	3	1	71.6	355.	5.00
					4	1	214.8	775.	3.62
					1	3	57.3	230.	4.03
					11	6	143.2	129.	.90
					Saplan.	1	358.0	1130.	3.15
					25	2	35.8	163.3	4.56

## RECAPITULATION.

No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	615.8	1600.0	2.60
2	465.6	800.8	1.72
3	386.6	995.6	2.60
4	214.8	360.0	1.67
6	236.3	153.0	.65
	1919.1	3909.4	
Average out-put.....			2.04

## RECAPITULATION.

No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	665.9	2306.0	3.46
2	336.5	598.3	1.78
3	422.4	963.0	2.28
4	350.8	577.7	1.65
6	143.2	189.0	1.32
	1918.8	4634.0	
Average out-put.....			2.42

1900.					1901.				
Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre	Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
25	2	250.6	700.	2.80	23	1	64.4	325.0	5.07
26	2	286.4	800.	2.80	24	1	93.1	498.6	5.35
16	4	143.2	400.	2.80	22	1	57.3	249.2	4.35
21	5	107.4	220.	2.05	21	1	107.4	436.2	4.07
14	1	43.0	258.	6.00	10	5	57.3	304.7	5.34
2	3	64.4	370.	5.78	15	5	171.8	355.6	2.06
6	3	35.8	191.	5.45	7 & 8	5	71.6	149.8	2.10
5	4	171.8	625.	3.65	18	4	35.8	55.0	1.57
10	5	14.3	78.	5.57	13	4	85.9	149.8	1.74
17	4	71.6	213.	3.00	27	4	243.4	481.2	2.00
23	1	121.7	775.4	6.40	1	1	18.5	70.0	3.78
24	1	93.1	572.9	6.16	1	4	57.3	158.4	2.76
22	1	85.9	300.	3.50	3	2	71.6	215.6	3.03
9	3	214.8	453.	2.11	4	2	214.8	623.0	2.91
4	1	21.5	65.	3.09	20	2	71.6	306.7	4.28
6	3	71.6	135.	1.90	22	1	179.0	720.0	4.02
					20	2	229.1	805.3	3.51
					Chamalca	1	501.2	1650.	3.29
					25	3	214.8	572.4	2.66

## RECAPITULATION.

No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	365.2	1971.3	5.40
2	537.0	1500.0	2.80
3	386.6	1149.0	2.97
4	386.6	1238.0	3.20
5	121.7	298.0	2.45
	1797.1	6156.3	

Average out-put..... 3.43

## RECAPITULATION.

No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	1020.9	3949.0	3.87
2	587.1	1950.6	3.32
3	214.8	572.4	2.66
4	422.4	844.4	2.00
5	300.7	810.1	2.69
	2545.9	8126.5	

Average out-put..... 3.19

1 9 0 2 .					1 9 0 3 .				
Section.	No. of cut	Acres.	Tons of sugar.	Tons of sugar per acre.	Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
25	3	71.6	37.8	.52	16	1	42.96	306.6	7.13
26	3	214.8	505.0	2.35	21	1	100.24	468.4	4.67
10	1	143.2	467.2	3.26	3	3	71.60	278.2	3.83
11	1	143.2	401.4	2.80	4	3	214.80	639.0	2.97
6	4	35.8	107.8	3.01	27	5	200.48	529.7	2.64
2	4	64.44	169.7	2.63	20	3	300.72	805.0	2.67
4 B	2	21.48	61.5	2.86	22	2	179.00	903.3	5.04
14	2	42.96	92.9	2.16	Chamalca	2	501.20	2109.5	4.20
5	5	171.84	410.1	2.32	1	5	78.76	248.9	3.16
17	5	71.60	147.3	2.05	25	4	78.76	283.3	3.59
9	4	121.72	273.0	2.24	26	4	214.80	819.2	3.81
23	2	186.16	1254.1	6.73	10	2	143.20	656.2	4.58
24	2	186.16	1142.1	6.13	11	2	143.20	529.0	3.69
22	2	85.92	505.8	5.88	4 B	3	21.48	91.6	4.26
10	6	71.60	409.6	5.72	1 A	1	143.20	814.0	5.68
21	2	107.40	665.	6.19	15	1	150.36	765.7	5.09
16	1	100.24	406.5	4.05	13	1	85.92	447.5	5.20
9	1	128.88	494.9	3.84	18	1	71.60	397.4	5.55
					12	1	71.60	433.1	6.04

## RECAPITULATION.

No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	515.52	1770.0	3.43
2	630.08	3721.4	5.91
3	286.40	542.8	1.90
4	221.96	550.5	2.48
5	243.44	557.4	2.29
6	71.60	409.6	5.72
	1969.00	7551.7	

Average out-put..... 3.84

## RECAPITULATION.

No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
1	665.88	3632.7	5.45
2	966.60	4198.0	4.33
3	608.60	1813.8	2.98
4	293.56	1102.5	3.75
5	279.24	778.6	2.79
	2813.88	11525.6	

Average out-put..... 4.09

1 9 0 4 .					1 9 0 5 .				
Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.	Section.	No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.
5	6	101.84	259.5	2.54	4	4	214.80	275.33	1.28
6	4	35.80	95.9	2.70	14	1	64.44	249.75	3.87
22	3	85.92	541.6	6.30	20	4	35.80	88.41	2.47
23	3	186.16	871.0	4.67	22	3	179.00	753.00	4.20
2	5	64.44	151.14	2.34	Chamalca	3	501.20	1966.16	3.92
24	3	186.16	963.4	5.10	1 A	2	143.20	822.03	5.74
10	7	71.60	280.1	3.91	4 B	4	21.48	89.51	4.16
9	1 & 2	250.60	1084.4	4.30	15	2	150.36	837.37	5.56
3	4	71.60	114.0	1.59	26	5	186.16	526.97	2.83
21	2 & 3	207.64	1207.3	5.80	12	2	71.60	413.83	5.77
16	2	143.20	680.8	4.75	13	2	85.92	467.85	5.44
17	1	57.28	319.1	5.50	18	2	71.60	511.14	7.13
25	1	107.40	653.6	6.00	22	4	85.92	444.43	5.17
19	1	107.40	357.7	3.33	20	1	264.92	1241.51	4.68
7	1	50.12	191.49	3.82	6	1	35.80	181.59	5.07
8	1	35.80	157.37	4.39	21	3	21.48	117.39	5.46
RECAPITULATION.					RECAPITULATION.				
No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.		No. of cut.	Acres.	Tons of sugar.	Tons of sugar per acre.	
1	358.00	1679.26	4.69		1	565.64	2763.35	4.88	
1 & 2	393.80	1765.20	4.48		2	522.68	3052.22	5.83	
2 & 3	665.88	3583.30	5.38		3	844.88	3543.95	4.19	
4	107.40	209.90	1.95		4	358.00	897.68	2.50	
5	64.44	151.14	2.34		5	186.16	526.97	2.83	
6	101.84	259.50	2.54			2477.36	10784.17		
7	71.60	280.10	3.91						
	1762.96	7928.40							
Average out-put.....				4.49	Average out-put.....				4.35

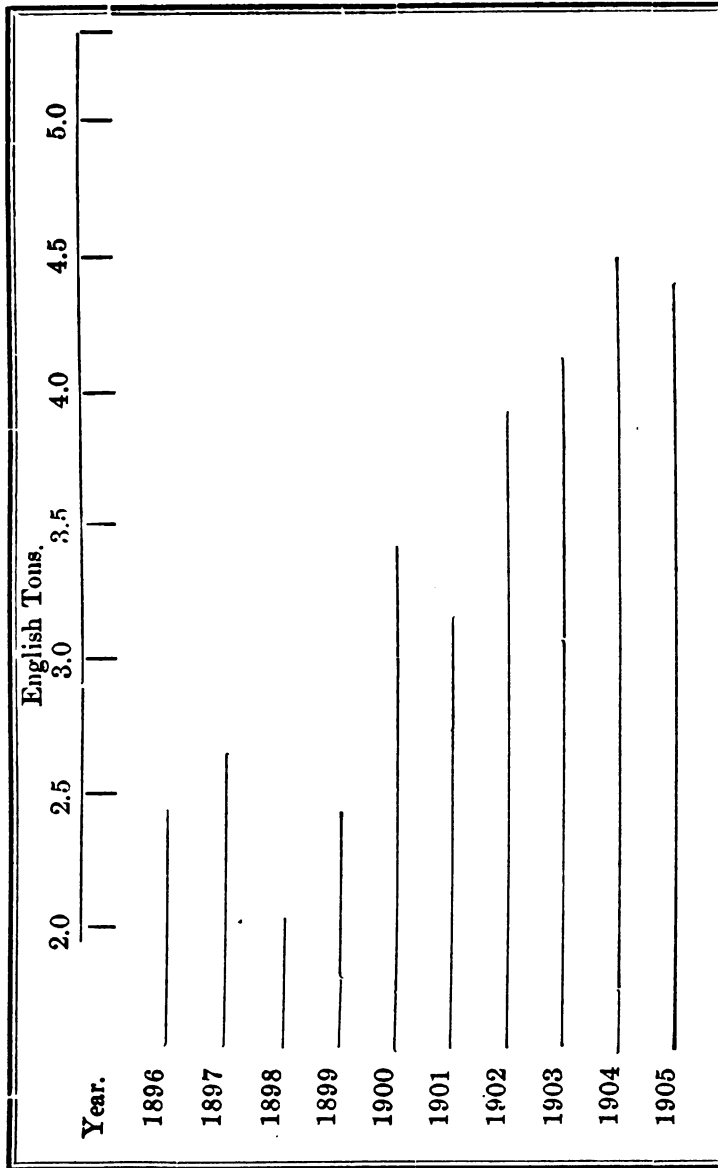


CHART SHOWING AVERAGE OUT-PUT OF SUGAR PER ACRE FOR TEN YEARS.

## EXPERIMENTING.

It would be clearly a waste of time and money to experiment to prove questions already understood and that have stood the test of experience; such, for example, as the reclamation of alkali land, for it is already known how it can be done. The things for the planter to elucidate by experiment are those in his line that are not yet fully understood, or have not been determined for his particular locality or conditions.

The experiments applicable for a sugar estate are connected with the work of field and factory. Although experimenting is generally associated only with the field work, it ought to play an equally important role in the factory.

Field experiments are concerned chiefly with fertilizer tests, variety tests, irrigation, cultivation, control of pests, and kindred questions of interest.

There is little need for a factory to experiment until it has introduced modern methods and machinery; after this has been done, experiments for saving labor, preventing losses of sugar, methods of boiling, clarification, and other factory processes, may be studied for the sake of improvement.

The essentials in all experimenting are: To diagnose all of the conditions as thoroughly as possible; to carry out the experiment perseveringly and to a finish; to make careful observations to detect the "point" of the experiment if it exists, no matter how obscured, and after getting it, to work upon it till the desired conditions are brought about or definite proof obtained that they cannot be brought about.

A few systematic field experiments have recently been begun at Cartavio. A small field was laid off in 20 plots in accordance with the regular methods. The experiments were as follows:

- Plot 1. Fertilizer applied—sheep manure and a mixture of Peruvian guano with sulphate of potash. (The mixture contained 6.5% nitrogen, 7.2% total phosphoric acid, 10% potash.)
- Plot 2. Same mixture of guano and potash, and a little sand.
- Plot 3, 4 and 5 were devoted to samples of commercial fertilizers sent for trial. The analyses were not given. Each plot represents a sample.
- Plot 6. Same mixture of guano and potash.
- Plot 7. Sulphate of potash.

- Plot 8. Nitrate of potash.
- Plot 9. Same mixture of guano and potash. The plot was irrigated only half as many times as the others, but the soil was cultivated after each irrigation.
- Plot 10. No fertilizer.
- Plot 11. Peruvian guano and bagasse ashes.
- Plot 12. Same as 11. Reserved for stripping cane.
- Plot 13. Peruvian guano and bagasse ashes. Cane kept clean of borers.
- Plot 14. Peruvian guano, bagasse ashes and a little nitrate of potash.
- Plot 15. Same as 11. Reserved for two dressings of fertilizer.
- Plot 16. Inoculating experiment for cowpea and alfalfa.
- Plot 17. Same as 11 with a small dressing of the mixture of guano and potash. Cane thinned out in the rows.
- Plot 18. Same as 17. Cane planted at twice the usual distance.
- Plot 12. Same as 17. Water run between the rows and not on the cane in rows.
- Plot 20. Guano, bagasse ashes, and chloride of potash.

The same kind of cane was grown on all plots, and the method of irrigating was the same except for Plots 9 and 19. The Peruvian guano used contained 8% nitrogen and 10% total phosphoric acid.

While the results will not be known until several months later, the experiments have already brought out some interesting points.

Plot 9 which has been irrigated only half as many times as the other plots, was cultivated after each irrigation; the cane on this plot looks as thrifty as the best and much better than some. The question of conserving moisture by cultivation is of special interest for Peru and further investigation in this particular might be advisable.

Of the fertilizer test experiments, Plot 1 presents the best appearance. Plots 20, 5, 6, 18, 14 are very good. Plots 13, 19, 8, are good. Plots 7, 2, 3, 4, 11, 12, 15, 17, are fair. Plot 10 is poorest of all.

#### PLANTING TOPS OR STEMS.

The question of the relative merits of tops and stems for seed-cane has long been discussed. Experiences have differed and no universal conclusion has been reached. The planting of tops is, however, the more widely practiced. In Peru, tops are invariably used.

Some experiments were tried to test the germinating power of the buds from tops and from stems.

Experiment N<sup>o</sup>. 1. The canes chosen were 21 mos. old. From the



1

2

No 1. SEED-CANE PLANTED IN WASHED ALKALI SOIL.  
No 2. SEED-CANE PLANTED IN UNWASHED ALKALI SOIL.



tops were cut fifty pieces each piece containing one bud; from the stems were also cut fifty pieces each containing one bud. The buds from tops and stems were planted in separate boxes. After three months it was found that 33 % of the buds from tops had sprouted while only 2 % of the buds from the stems had sprouted.

Experiment N<sup>o</sup>. 2. This was carried on as in Experiment N<sup>o</sup>. 1 except that the canes used were only 14 months old. 92 % of the buds from tops sprouted, and 78 % of the buds from stems.

This would seem to indicate that it would not be advisable to use the lower portion of the stems for seed-cane in Peru; at least unless the cane were especially grown for seed and cut prior to maturity. This is still more evident when it is remembered that a given length of top contains more buds than the same length of stem.

The experiments could not of course give any idea of the relative strength of the plants grown from top and stem buds.

Tops of canes were split in half lengthwise and planted; they have given good plants and are still growing in the Experimental plot.

#### WASHING ALKALI SOILS.

In order to show the effectiveness of washing alkali soils, soil was taken from an alkali spot on which cane would not grow and placed in two tubs. The soil in one tub was flooded with water and thoroughly drained; this was repeated several times. Cane was planted in the tubs. The seed-cane planted in the washed soil sprouted and grew well (cane N<sup>o</sup> 1 in illustration), while that in the tub of unwashed soil did not even sprout (cane N<sup>o</sup>. 2). Such a soil after being washed would become very productive and would require little fertilizer.

#### DETERIORATION OF CANE.

Experiments were made to determine the keeping quality of some Peruvian canes after cutting.

Ten canes were selected from the conductor for the experiment. They were so cut, arranged, and sampled that each lot of cane reserved for analysis contained tops, butts, and middles, of the stems.

The result of the first experiment showed the total loss of sucrose in 120 hours to be 8.2 % of the sucrose contained in the cane.

Figures relating to the repeated experiment are given below, the total loss in 96 hours amounting to about 10 % of the sucrose contained in the cane.

Hours cut.	Sucrose in cane.	Moisture in cane.
	%	%
	14.20	68.3
24	13.80	67.9
48	13.50	67.5
72	13.40	67.1
96	13.00	66.8

The loss of sucrose in cane after cutting is less here than in some other countries. This is accounted for by the dryness of the climate and that the canes are more mature when cut than in countries where there is greater humidity or where the winters are cool. It seems to be true that the more mature the cane, the smaller will be the loss of sucrose after cutting.

#### SOIL INOCULATION.

Green manuring is not generally practiced in Peru. Some of the soils would undoubtedly be benefitted by it and by inoculation with nitrogen-fixing bacteria. Uncultivated legumes frequently grow in the cane fields; their roots, on examination, have been found to have a fair supply of nodules, showing that the soils contain some nitrogen-fixing bacteria. The alfalfa of the country seems to be sparingly supplied as the roots so far examined have had few and small nodules.

Experiments in soil inoculation were carried on at Cartavio, with the cowpea and the alfalfa of the country. The roots of the inoculated pea plants had larger nodules than the uninoculated. Alfalfa roots from both the inoculated and uninoculated soil showed very few nodules.

The experiment with alfalfa should be repeated as there may have been some error in carrying out the directions for inoculating.

In connection with the regular laboratory work on cane, some special analyses were made bringing out several observations that may be of interest for further investigation.

From fifteen partial analyses of canes grown at Cartavio, the following are given to show the variation in the constituents of these canes.

	a.	b.	c.		a.	b.	c.
Nitrogen in cane,	.046	.048	.046.	Ash in cane,	.50	.65	.52

## IN ASH.

	a.	b.	c.		a.	b.	c.
Insol. matter.	39.1	38.2	46.8	Magnesia.	2.1	1.4	3.6
Potash.	19.3	24.2	16.2	Iron & alumina.	9.0	6.2	8.9
Soda.	2.4		3.6	Phos. Acid.	9.9	9.0	9.4
Lime.	2.2	1.8	2.5	Sulphur Trioxide.	9.0	9.2	10.4

When it is remembered that the soils contain large quantities of lime, the percentage of lime in the cane ash is low, being in no greater proportion than in canes grown on soils with only fair amounts of lime.

A number of analyses were made of the tops and middles of mature canes, and of young canes, with special reference to the percentage of chlorine in the ash. The observations were that the upper portions of the tops of the canes contained much more ash than the middles, and that the percentage of chlorine in the ash of the tops was very much greater than in the ash of the middles.

The analyses of the stems of six months old cane showed the ash to be much higher than in mature cane, as was also the chlorine in the ash. The ash and chlorine in ash appeared to vary with the degree of maturity of the cane, the young cane, or young portions of mature cane, containing chlorine in considerable quantities, while the mature portions of the cane contained but small amounts.

A series of analyses of juices was made for ash, chlorine in ash, gums and reducing sugars. There seemed to be a close relation existing between ash, chlorine in ash, gums, and often, reducing sugars—the higher the gums, the higher the ash and chlorine in the ash.

From these and other analyses, and from general observations, it would seem that under the conditions in Peru, the degree of maturity is the most potent factor in determining the character of the cane, and that it is largely responsible for the variation in the amount of organic and mineral substances, such as gums and ash, that are said to influence the manufacturing qualities of the juice.

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The Progress of Peru's sugar industry within the last decade has been marked. The exportations of sugar have increased in that time from about 72,000 to 132,000 metric tons, as will be seen by the export list.

Metric Tons.	Metric Tons.	Metric Tons.
1896.....71,735	1899.....103,706	1902.....117,361.
1897.....105,463	1900.....112,222	1903.....127,673.
1898.....105,713	1901.....114,637	1904.....131,957.

The production of sugar at the present time is probably in the neighborhood of 150,000 tons.

Judging from the results at Cartavio and what has been learned of other estates, it would be conservative to estimate that the out-put of commercial sugar from the acreage of cane now annually cut could be increased fully fifty per cent by intensive cultivation and the introduction of the most efficient machinery, particularly milling machinery.

In addition to the sugar lands, cultivated and uncultivated, now under the water system, many thousands of acres could be put into cultivation if the mountain water supplies were made available. It ought not to be a very difficult problem to control and conserve the super-abundant waters of the flood season.

Satisfactory flowing wells have been sunk near Lima, and it is quite probable that other flowing wells could be successfully sunk on estates that care to increase their water supply.

The cost of producing sugar should be less than in many other countries. As the lands are level or gently sloping, all kinds of labor-saving machinery can be utilized. Since grinding can be continued throughout the year, proportionately smaller factories are sufficient, and labor can be better regulated both in field and factory. The labor system is good and the price of labor is reasonable. As yet it has not been possible to get full or satisfactory figures leading up to the cost of the production of sugar, but the managers of several of the best estates have placed the cost at about 1.2 cents (gold) per lb.

Peru is essentially a sugar growing country, possessing the conditions that should, under systematic development, make it rank high among cane sugar countries.



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